The Engineer

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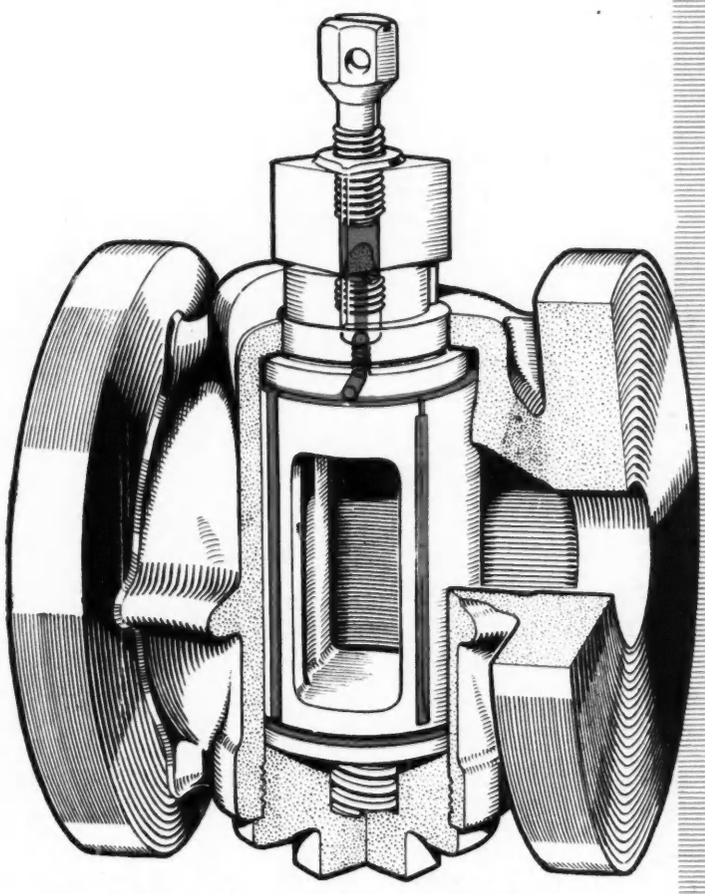

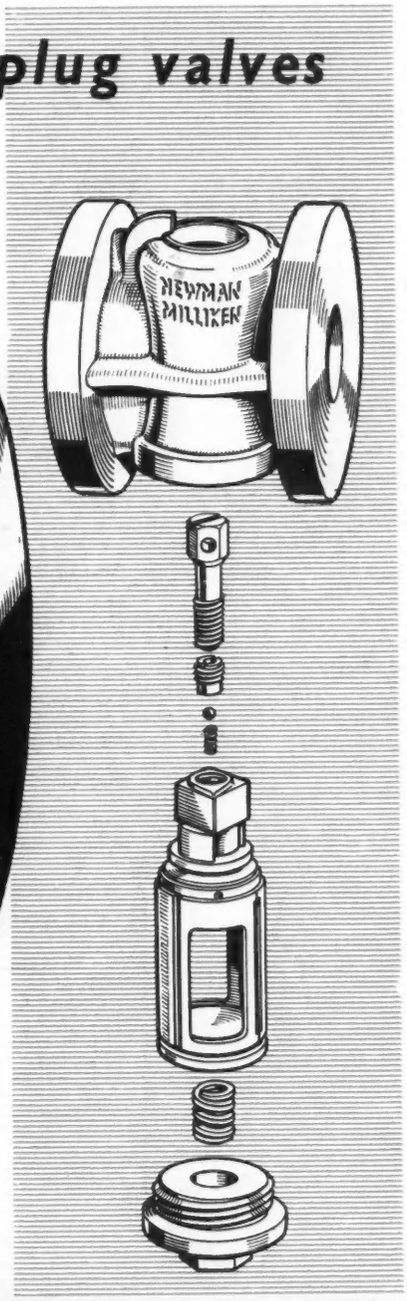

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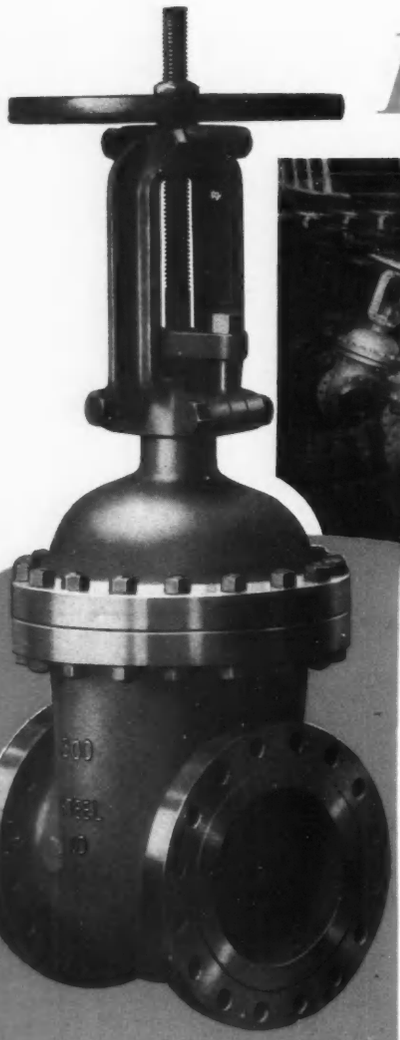

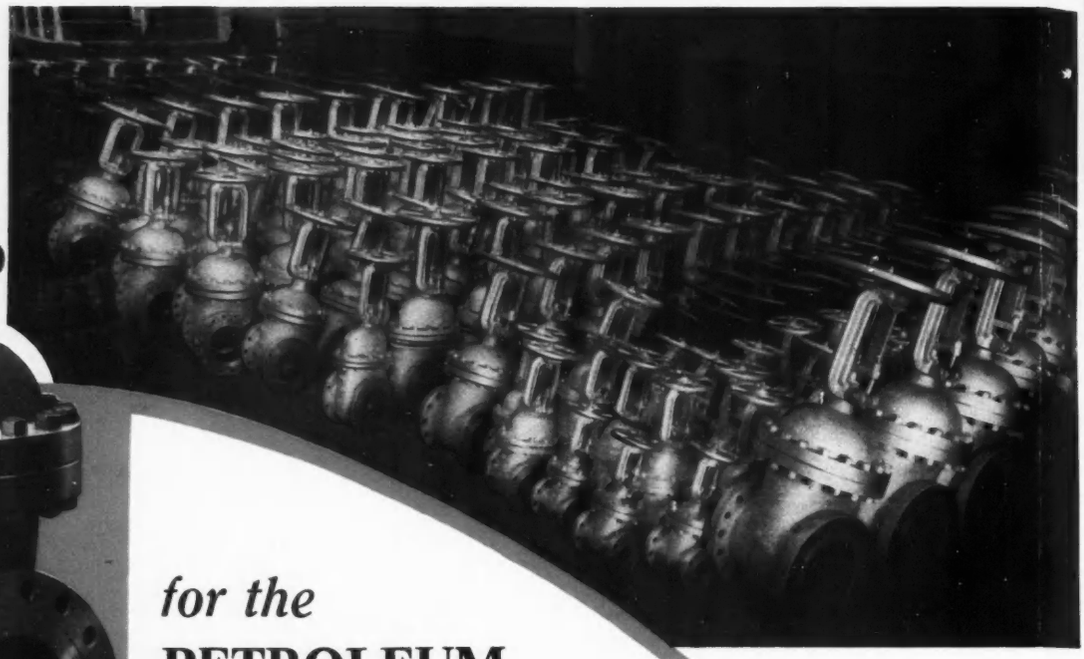

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THE ENGINEER

VOL. 203 No. 5292 JUNE 28, 1957

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CENTENARY OF THE SCIENCE MUSEUM

Last Monday the Science Museum in South Kensington, London, became 100 years old. On June 24, 1857, the doors of what was then known as the South Kensington Museum were thrown open. A book has just been published by H.M. Stationery Office in recognition of this centenary. The concept of such a museum seems to have arisen out of the holding of the Great Exhibition in Hyde Park in 1851. Two years after the holding of that Exhibition a Department of Science and Art was set up under the Board of Trade "to increase the means of industrial education and extend the influence of science and art upon productive industry." One of the activities of the new Department related to the setting up of museums. But first ideas about the objects to be put on view at the South Kensington Museum appear, 100 years later, somewhat confused. There seems to have been a vague but ill-digested idea that the new museum should have as its main object the education of artisans and the instruction of teachers. The range of exhibits included artistic objects, animal products and examples of things considered good to eat! On the whole the scientific exhibits seem to have been rather subsidiary. It was not until 1884 when a collection of machinery formed by the Commissioners of Patents was transferred to South Kensington that scientific objects began to predominate amongst the exhibits; and it was not until 1909 that, as a consequence of a recommendation made by a Select Committee in 1897, the art exhibits were finally withdrawn to the new Victoria and Albert Museum and the museum began to look more like the Science Museum we know to-day. At that date, 1909, a Committee under the chairmanship of Sir Hugh Bell made recommendations which in principle still rule over the policy of the Museum. Its objects are to enlarge the common store of knowledge about the development of science from earliest times up to the present day, and to present that knowledge to the visitor in such a way that he will be attracted and interested and have his imagination stirred.

It cannot be said, we think, that to-day the Science Museum is fully achieving the latter of those objects. For to the layman much that is on view appears esoteric. It cannot be easily comprehended without a greater knowledge than he is likely to possess of the elements of the science or technology involved. Nor is it made at all clear what have been the exciting effects upon the life of the community of the great technological advances achieved in the last century or two. By comparison the Victoria and Albert Museum, an offshoot of the original South Kensington Museum, appears to a visitor not esoteric at all and it presents an easily assimilated record of the development of applied arts over the centuries. The connection with human living standards is obvious at once. The Science Museum says to its visitors "Here is Science and Applied Science." But it fails to say "This is what the advancement of technology has done to affect your life." Nor does it clearly enunciate some of the very simple elementary principles upon which engineering design is founded. What is possible along such lines and how effectively a visitor can "have his imagination stirred" by adequate presentation is demonstrated by certain museums abroad, more particularly that at Chicago, which appears to have as its primary object that of showing visitors how great and how beneficial has been the impact of engineering on their lives. That attitude is epitomised, to mention but one example, by a group of four full-size exhibits showing a room in a farm house at four different dates covering a century. These exhibits illustrate very convincingly how standards of comfort and convenience have been enormously improved in lighting, heating, clothing, food storage, cleanliness, and by disposal of wastes. Additionally, by permitting a view through an open window of the surrounding country they illustrated how manual labour has been lightened by the use of machinery and the freedom to travel extended by the development of the motor car. Again in that museum care is taken by the installation of certain equipment to illustrate qualitatively certain simple principles. Ingeniously designed equipment allows the visitor to perform simple experiments illustrating the existence of "inertia," the preservation of angular momentum, the triangle of forces and many other things. In this attractive way the uninitiated visitor is given an elementary grasp of engineering principles.

Why does not the Science Museum, which has on view objects of historic interest that are the envy of the world, pay more attention to the education of the public into the effects of advancing technology on the life of the community? The answer very probably lies in the fact that it has never had sufficient space available. As long ago as 1909 the Bell Committee recommended that a total floor space of 500,000 square feet should be provided; but three years later only 108,000 square feet were available. The Committee suggested the erection of a new building in three blocks. So far only one of these blocks has been completed; but a second is under erection. The space now

available, though larger than in 1912, is in fact smaller than in 1939, when certain temporary structures were in use. It is because so little space is available that the visitor to the Science Museum to-day so often feels battered mentally by the crowd of objects meriting his attention. More space would permit a more adequate and more illuminating presentation of the history of science and technology. Furthermore, if the Museum is to stress in the future the effect of applied science and the advancement of technology on the lives of people, as we think it should, much more space will be needed. The exhibits at the Science Museum need to be at least as adequately housed as those of the Victoria and Albert Museum across the road.

ELECTRICAL POWER FOR INDUSTRY

In his presidential address to the British Electrical Power Convention last week Sir Josiah Eccles presented a thoughtful and thought-provoking analysis of Great Britain as a country that must export her manufactures to pay for her essential imports of food and raw materials. From this well-trodden ground Sir Josiah moved on to discuss the part that is being played by electricity in helping to preserve a balanced economy. He did well to remind his audience of Britain's share in current technical progress. For it is easy to think of the electricity supply and manufacturing industry as being still so preoccupied (as it was in the immediate post-war era) with the task of making and installing generating plant as rapidly as possible, that little effort can be spared for technical improvement. On the contrary, having reduced the plant deficiency to manageable proportions by about 1953, the electrical industry quickly began to apply recent technical advances to the manufacture of generating plant of improved efficiency and reduced cost. In particular, the Central Electricity Authority relinquished the 30MW and 60MW standards for generating sets and placed orders for numbers of larger units, of 100MW, 120MW and upwards. To-day manufacturers are engaged in the building of 200MW turbo-alternators, using only 22½ per cent of the copper and 50 per cent of the steel that was needed, per megawatt of output, in the 30MW alternators of 1946. These remarkable economies in the use of basic raw materials deserve more publicity than they have hitherto received. Further similar savings may be expected from the projected 275MW and 550MW cross-compound sets. The savings are not confined to copper and steel, for it is worth emphasising that the 200MW sets now being built are only very slightly bigger in overall length than the 60MW sets of a decade ago. The bigger sets, therefore, offer prospects of reductions in the cost per megawatt attributable to civil engineering and building.

At the same time there has been a substantial increase in the amount of generating plant commissioned annually by the C.E.A. As Sir Josiah pointed out in his address, the new plant put into service in 1956 totalled 1937MW, compared with only 370MW in 1947. Now the electrical manufacturing industry is capable of installing 2500MW of generating plant annually in British power stations, besides meeting the demands of export markets. But these achievements leave no room for complacency when one considers what has been and is being done in other countries. Russian expansion, for example, has been even more remarkable. Her installed generating plant capacity has grown from 10,700MW in 1945 to 36,900MW in 1955. Russia's planned capacity by 1960, the end of the second five-year plan, is expected to be 75,000MW. These figures, given in the recently published report on a visit last year to the U.S.S.R. by a British electricity supply delegation, show that Russia's generating capacity is being doubled every five years, whereas Britain's capacity is being doubled approximately every ten years. Similarly, the quantity of electricity sent out during the present five year plan is expected to increase by 17·6 per cent per annum, compared with an annual increase of about 10 or 11 per cent in Great Britain.

The significant fact about the growth of electricity output in the U.S.S.R. is that about 80 per cent of the commercial output is sold to industry, leaving only about 19 per cent for domestic, commercial and agricultural use. In Great Britain, on the other hand, a much smaller proportion of the total is used by industry. Russia, in fact, is deliberately concentrating on the task of increasing the horsepower available to each worker in industry, at the expense of any immediate rise in the standard of living. The advantages that this policy will confer upon Russian industry as a producer and as a potential rival in export markets cannot be ignored. This formidable industrial challenge that is implied in Russia's electrical power programme suggests an answer to those critics here who claim that Great Britain is spending more than she can afford on power development. The question is, not whether this country can afford such programmes, but whether, in the long run, she can hope to compete without them.

CAMBRIDGE ARTS AND SCIENCE COURSE

The recent announcement that a new degree course is under discussion at Cambridge which would combine arts and science studies is not, of course, of direct interest to engineers, except in the sense that it is no doubt hoped that the course will ultimately provide men of directorial ability, some of whom may find their way into engineering. Yet since this journal has often proved critical of the tendency to place educational courses in the two watertight compartments of "arts" and "science" comment comes not wholly amiss. It might be expected that we should welcome the proposal; and in the sense that it reveals a university realisation that no man can be really broadly educated unless he has some understanding both of humanities and science, we do welcome it. Yet we question whether, in fact, the course is well conceived. It is apparently suggested that two years of the course will be devoted to an Arts subject followed by one year devoted to a Science subject. This arrangement surely would continue to accentuate and perpetuate the unsatisfactory divorce between arts and sciences. The kind of course which would be much more welcome would be one in which throughout the three years of the course related arts and science subjects were "married" and simultaneously studied. Suitable subjects are certainly not wanting. For example, there immediately occurs to us, as engineers, a course in the history of the last two hundred years which would trace the influence on the community of the impact of advancing technology.

The Engineer
100 Years Ago
(JUNE 26, 1857)

"FORSYTH'S IMPROVEMENTS IN LOCOMOTIVE ENGINES"

"Some experiments have lately been made by Mr. Forsyth, of Messrs. Sharp, Stewart, and Co's. works at Manchester, on a new method of heating the cylinders and feed water of locomotive engines. A plate of wrought-iron, cut to the shape of the smoke box, is placed in an inclined position within it, its top edge resting against the tube plate. This causes the products of combustion to descend after leaving the tubes, and to travel entirely round the cylinders previously to passing off by the funnel. But this is not all, for at the upper part of the smoke box is placed horizontally a new water heater, which consists of a chamber filled with short tubes, through which the heated gases pass in their way to the funnel. The short tubes are divided into rows by diaphragms, which cause the feed water to take a long and circuitous route in its way to the boiler, thus raising its temperature to the boiling point.

"The effect of this water heater in uniformly dividing the current of gases as they pass through it is rather singular, as it tends to equalise the work done by all the boiler tubes, only allowing the central or upper ones to pass their due proportion of the products of combustion, thus keeping all the tubes clean and preventing any deposition taking place in them. Another improvement consists in attaching to the locomotive a small donkey engine for feeding the boiler, and which is so arranged as to draw the water through the heater when the engine is standing still or while getting up full steam. When the water is not required to pass into the boiler, it is allowed to circulate in the heater and back into the tender, thus making continued use of all the heat in the smoke box. A third improvement consists in fitting to the end of the blast pipe a regulator in the shape of a hollow cone, which has a number of vertical slits round it, and which can be opened or closed at pleasure, thus regulating the draft with great nicety."

A Seven Day Journal

"Cutty Sark" Opening Ceremony

ON Tuesday afternoon, Her Majesty the Queen, accompanied by H.R.H. the Duke of Edinburgh, visited Greenwich to open formally the "Cutty Sark." The ceremony marked the completion of the work of preservation which has been carried out by the "Cutty Sark" Society. It was in February, 1954, the famous clipper left her moorings at Greenhithe and proceeded to a berth in the East India Import Dock as the first stage of her last voyage to her permanent home. Later in the year the ship sailed to Greenwich and entered the dry dock through a channel cut for that purpose. The dock, which has been specially built to receive the clipper, is of mass concrete and is 265ft long by 60ft wide. Since entering the dock work has gone forward in renewing and repairing the timbers and rigging of the ship. Following the royal tour, the clipper was opened to the public as from Wednesday last, June 26.

The International Geophysical Year

ON Monday next, July 1, the International Geophysical Year begins officially. This week there has been published a booklet entitled *The International Geophysical Year* (H.M. Stationery Office, price 3s.), which has been prepared for "Unesco" by Werner Buedeler. This booklet outlines what is being attempted by the fifty-two nations which are participating in the events of the International Geophysical Year.

The first world-wide collaboration in geophysics, known as the First International Polar Year, took place about seventy-five years ago; it was followed, in 1932–33, by a Second Polar Year. The "year" beginning on Monday will involve not only the polar regions, as did the first two enterprises, but all exposed land area, the oceans, the atmosphere and solar activity. The U.S.A. plans to send up small satellites into orbits at altitudes up to 300 miles or more; scientific instruments will be installed in them to record atmospheric and cosmic data which will be relayed back to earth by small radio transmitters. Rocket exploration of the atmosphere is also to be undertaken individually by Britain, France, Russia and Japan. Measurements and recordings will be taken of auroral lights, meteoric particles, geomagnetic disturbances, cosmic rays and conditions in the ionosphere. Over a hundred geomagnetic stations are being set up throughout the world. In the booklet which he has written, Mr. Buedeler deals with all these events. The "year," he says, is a scientific enterprise which will lead to greater progress in geophysics than ever before.

Institution of Production Engineers

THE Institution of Production Engineers has announced the formation of a specialist group on materials handling, under the chairmanship of Mr. A. G. Hayek. The purpose of this group, it is stated, is to provide a central forum for those members of the Institution having a special interest in materials handling, which for this purpose is defined as "the study of the handling or other movement of materials before, during or after processes in every kind of industrial activity." The main activities of the group will be the organisation of conferences and lecture meetings, where original papers on materials handling may be presented; the preparation of case studies for publication; the establishment of working groups, and, generally, the stimulation of interest in and the building up of a body of knowledge of materials handling directly and by liaison with other bodies. A syllabus for the formal teaching of materials handling has been prepared and the group is taking steps to have this syllabus accepted by technical colleges and other educational institutions throughout the country. It is hoped that some recognised award will be accorded to graduates of this course.

Berth at Tilbury Docks

THE new No. 1 berth and passenger terminal at Tilbury Docks was officially opened on Monday last by Lord Waverley, the chairman of the Port of London Authority. This work, which has cost some £1,590,000, was started in 1953, and has involved the construction of a quay 842ft long with a return quay 240ft long at the west end. The quay is situated on the north side of the main dock, adjacent to the west branch dock, and the main dock has been widened from 600ft to 900ft, to give increased manœuvring area for ships and to enable larger vessels to turn into the west branch dock. The quay gives a depth of water of 42ft 6in below Trinity high water, and will accommodate the largest ships now using Tilbury Dock. In order to obtain a suitable foundation on gravel or chalk, a depth of 50ft or more of clay had to be penetrated, and the quay itself is carried on thirty monoliths, each 30ft square and varying in depth from 50ft at the east end to 72ft towards the west end. Two railway tracks and an 18ft gauge crane track have been installed along the quay, which is equipped with four 3-ton and one 5-ton electric cranes. The single-storey transit shed is of reinforced concrete construction, with barrel vault shell roofs. These roof shells are generally 122ft long by 41ft by 30ft 6in radius, except over the reception hall, where the shells are 61ft long. The new works were designed and carried out under the direction of Mr. G. A. Wilson, the chief engineer of the P.L.A., by Holloway Brothers (London), Ltd., as the main contractor.

Nine-Storey Building Frame of Precast Concrete

IN THE ENGINEER of February 17, 1956, we described a building framework of precast concrete developed by Concrete, Ltd. This design was characterised by prestressed beams and other elements in ordinary reinforced concrete, with carefully designed joints where the steel reinforcement was sufficiently rigid, where necessary, to allow complete "boxing out" of a unit such as a two-storey column, so that joints and "topping" could be completed *in situ*. The general principles of this design have since been developed further, and the company has now erected the structural frames for nine-storey blocks of flats by this method. These frames are believed to be the first of their kind built almost entirely in precast concrete, and are claimed to have appreciable advantage, principally in cost, and, secondly, in speed of erection.

The nine-storey blocks are being erected for the borough architect on a large housing estate, of 160 acres, on reclaimed land at Barking. Structurally, they are characterised by five-storey column elements and by floor and roof slabs 7ft 6in in width, which are extensively used in place of the more normal 14in wide floor units. The five-storey column elements are over 40ft in length. Five, three and two-storey column elements are needed in the entire frame, and the columns are staggered vertically, as erection proceeds, so that each new column element erected can be braced to adjacent columns already fixed in position. Four screws are left protruding at the top of a column element; the lower end of the element to be spliced on has a steel plate welded to reinforcing bars left protruding from it, and by registering the plate on the screws, and securing it, top and bottom, with nuts, a correctly aligned and levelled splice is made.

The nine-storey blocks are the central architectural embellishments of the estate, and they have been designed as a sort of "H"-shape in plan, the two wings of the "H" being short and curved. Thus, the precast frame is not on a rectangular grid, and curved beams are used in one position. Staggering the column joints was also considered advantageous architecturally, where the columns are exposed in the accented panels of the elevations.

International Congress on Combustion Engines

THE 1957 International Congress on Combustion Engines, which opened in Zurich on Monday, June 17, and ended on Saturday last, was attended by about 700 delegates, including 100 from Great Britain, and their ladies. The Congress was opened by Monsieur P. C. Tharlet, the president of C.I.M.A.C., and the delegates were welcomed by Professor H. Pallman, the president of the Council of the Swiss Federal Institute of Technology.

A lecture entitled "Reciprocating Engines and Turbines in Internal Combustion Engineering," by Professor W. Traupel, followed the opening speeches, and the reading and discussion of the twenty-five papers presented at the Congress began at the afternoon meeting. The papers dealt with various aspects of the development of turbocharged four-stroke and two-stroke diesel engines covering a wide range of powers and applications, and with the progress made in the development of the gas turbine and the free piston gasifier. On Saturday morning the final papers were read and the technical conference was concluded by Professor M. Roy, who gave a lecture in which he reviewed matters relating to the Congress and discussed questions concerning the progress of the gas turbine and the introduction of supercharging. He referred to problems related to energy balance and suggested that materials were the main factor in determining the rate of progress. During the Congress the delegates were able to make tours of a number of Swiss engineering works, and on Thursday evening the official banquet was held at the Kongresshaus, where the entertainment included a display of folk dancing and the presentation of folk songs.

Gas Cooling in Power-Producing Nuclear Reactors

By R. J. BEALE, Ph.D., B.Sc. (Eng.), A.M.I.Mech.E.*

Much has been written on the choice of a suitable coolant for different kinds of reactors, but the use of a gas is not generally treated separately or in much detail. Since the first stages in this country's programme for power generation by nuclear reactors are based on gas-cooled reactors, it is pertinent to discuss the merits and disadvantages of a gas as a coolant, and of the gases which may be used.

THE kind of reactor generally considered here is that in which the fuel, in the form of separate elements, is contained within the core in channels passing through the moderator. Heat must be continuously removed from the surface of these fuel elements and transported to the prime mover in use. This removal of heat from the core is carried out by forced convection to the coolant fluid, which is then pumped through an external heat exchanger, where the secondary fluid serving the heat engine (probably steam) receives the heat. Energy will be expended in this forced convection process and it must be taken from the reactor energy output ; this energy will be dissipated in forcing the coolant through the fuel element channels, the external heat exchanger, and the connecting ducting.

Inherently, gas is a poor medium for the transport of heat and in cases where a coolant can be chosen purely for its heat transfer performance a gas would not often be used ; a possible exception would be air where this is the surrounding medium and hence available without separate containment. The film heat transfer coefficient for a gas is very much lower than that for a liquid, and its low density means that high velocities, and hence high energy losses, are necessary. However, in a nuclear reactor the limitations imposed by both nuclear and constructional requirements result in a gas having a number of advantages not enjoyed by liquids ; unfortunately, its use itself imposes limitations on a design, particularly in restricting the power output obtainable from a given physical size of reactor core.

It must be remembered that from nuclear considerations the coolant is an extraneous material in the core. It should therefore have as low a capture cross-section for thermal neutrons as possible. (This is desirable for safety reasons as well as for neutron economy; the loss from the core of a coolant having high neutron absorption would give an immediate increase in reactivity which could be dangerous.) The reduction of parasitic neutron capture by the coolant is, of course, of particular importance when the fuel used is natural uranium.

With natural uranium reactors the choice of a coolant is very restricted. Of the possible liquid coolants heavy water is the most desirable from a nuclear aspect, but cost considerations would generally preclude its use, particularly where the leakage probability is high; light water is possible at low temperatures, but its neutron absorption is high enough to raise doubts on safety should the coolant be lost from the core. The natural uranium reactor requires a large core size and hence a large containing vessel for the coolant. Very high pressures cannot, therefore, be used, so that, in order to prevent boiling of the coolant, temperatures must be restricted and would generally be too low to give an acceptable heat engine cycle efficiency.

* The General Electric Company, Ltd. (Atomic Energy Division).

Of the liquid metals bismuth is possible from the nuclear aspect, but high cost and poor availability as well as engineering problems would probably prevent its use in the large natural uranium reactor core. Organic liquids such as diphenyl and terphenyl are possible as combined coolant and moderator. They would probably not be usable with natural uranium and, in any case, appear to have their greatest advantage in the small output reactor, possibly in propulsion reactors. There is, moreover, still very much to learn about their properties for this application and much work would be necessary before their suitability could be proved. This leaves the gases as possible coolants, and a few of them, which will be treated in detail later, are very favourable from the nuclear aspect.

Regarded as a heat transfer medium, a coolant would ideally have a minimum mass flow for any given temperature rise through the core, with the maximum quantity of heat removed, and it has been shown† that for a cooling channel, broadly :

$$\frac{P}{Q} \propto \frac{1}{M^2 C_p^3}$$

where

P is power required to pump coolant through channel.
Q is heat removed from channel.
M is molecular weight of coolant.
C_p is specific heat of coolant.

The ratio should, of course, be a minimum which means that a coolant should have high values of density and specific heat. A gas has generally a low density compared with a liquid, but the density can be increased by pressurising the coolant system ; it will be seen that the P/Q ratio varies inversely as the square of the density and hence of the pressure. It is necessary, therefore, that the core should be contained in a vessel capable of withstanding the highest pressures possible consistent with the size of shell required and the thickness of plate that can be welded. In spite of the pressures possible (with present designs, in the region of 100–200 lb per square inch), the volume of gas required is still large and coolant channels must be correspondingly large, which means that the core is increased in size, although the disadvantage would be smaller with natural uranium, as the core required here would in any case be large ; neutron losses from the core by streaming in the coolant channels can, however, be very significant with these large channels.

A rather similar disadvantage exists with gases regarding the heat exchangers between the gas and the working fluid of the heat engine attached. Larger passages and surfaces are required, resulting in a very large exchanger, which, of course, must also be under pressure in the same way as the rest of the coolant circuit ; such heat exchangers are therefore often heavy, unwieldy and costly pieces of equipment.

† Diamond and Hall, "Heat Removal from Nuclear Power Reactors," Symposium on Nuclear Energy, March, 1956, *Inst. Mech. Engineers.*

As previously mentioned, the film heat transfer coefficient with a gas is, in general, low ; therefore, either a large temperature difference must be maintained between solid surface and gas, or the area for transferring heat must be increased. In all cases there is an upper temperature limit at which fuel element materials can be run ; in most cases it is too low to permit of a considerable temperature difference between fuel element surface and coolant while still maintaining a sufficiently high coolant outlet temperature to give an acceptable heat engine cycle efficiency and design. The alternative which must normally be adopted is to allow the largest possible area for heat transfer, either by extended surfaces, such as fins, on the fuel elements, or by using fuel elements of thin sections so that the ratio of primary surface to volume of fuel is large. The result of "spreading" the fuel in the channel by the use of thin section fuel elements is a loss of available reactivity, so that with natural uranium as the fuel a solid rod, or similar shape, is usually essential, and thus extended surfaces are required. Very elaborate finning may be necessary ; the development of the most suitable surface must generally be done experimentally and is often a costly and time-consuming process. If some degree of fuel enrichment is employed, the use of thin section fuel elements having a large primary surface can give comparatively good heat transfer with a gaseous coolant, and it is possible to produce such elements in a reasonably simple manner.

In addition to the previous conditions which must be met by a coolant, the following are also important :—Stability under irradiation, and possible corrosion of coolant circuit and core materials or other chemical attack. In a power-producing reactor the coolant circuit will be a closed loop and the build-up of radioactive isotopes in the system would necessitate shielding of the whole coolant system against gamma radiation ; the production of such isotopes in the coolant under irradiation is thus most undesirable. A major advantage of the gases treated in detail here is that induced activity is small, and hence no shielding of the heat exchangers is required.

Carbon Dioxide.—The most-favoured and most-used gas to date has been carbon dioxide. This is a good choice for a moderately rated reactor, but it is not outstanding as a gaseous heat transfer medium and, hence, the specific rating of a carbon dioxide cooled pile is limited. The gas has a low specific heat and therefore the mass flow required through the core is rather large ; consequently, although the density is reasonably high, pumping power becomes very considerable at higher reactor ratings. It is, however, cheap, easily obtainable and compatible with many structural materials, and with graphite, at reactor temperatures at present being considered. The possibility of a significant reaction between carbon dioxide and graphite at higher temperatures must, however, be borne in mind. The neutron capture cross-section of carbon dioxide is small enough to be almost negligible and it can thus be used with natural uranium fuel. The somewhat low thermal conductivity of the gas means that considerably extended surfaces, such as deep fins, can be used with advantage with this gas ; its use therefore encourages elaborately finned fuel elements and the use of canning materials of fairly high thermal conductivity, which may restrict the possible canning materials.

Helium.—The great advantage of helium

is its chemical inertness. The fairly high specific heat means that for a given thermal output the mass flow of gas is low, but, on the other hand, the large volume flow resulting from the low density means that the blower power required to circulate it is actually rather greater than for CO_2 at the higher gas temperatures. The capture cross-section of helium to thermal neutrons is negligible and, hence, it is very attractive from the nuclear standpoint. Unfortunately, its very high cost and poor availability in this country means that it cannot be used here in large power-producing reactors requiring a large quantity of coolant in the circuit. Its use would necessitate recovery of the gas when releasing pressure, and means to prevent loss when charging or discharging fuel under load. In spite of these drawbacks, it may well be the best coolant for a small, high-temperature reactor ; in such a reactor chemical attack by the coolant on the structural and core materials would be a major problem with any but an inert gas.

Hydrogen.—As a heat transport medium, hydrogen is supreme among the possible gases ; its very high specific heat results in a comparatively low mass flow rate, so that although its specific volume is large, the power to circulate it is of the order of one-fifth to one-tenth (depending on temperature) of that required for CO_2 at the same heat output. However, a number of difficult problems are posed when the employment of hydrogen is considered.

At high temperatures and pressures hydrogen will embrittle and decarburise mild steel, so that pressure vessels, and any attached ducting as well as the heat exchangers would possibly need to be of either stainless steel or, preferably, alloy steel, which would increase cost ; whether this would be necessary at reactor pressures and temperatures would have to be settled by experiment. Further " in-pile " experiments to find the effect of irradiation on such reactions would also be necessary. Diffusion through containing materials is another problem of particular importance in the case of the fuel element. Hydrogen reacts with metallic uranium to form uranium hydride of lower density than the metal, and the resultant swelling could burst the canning material round the fuel element. The use of metallic uranium with hydrogen, therefore, would not generally be feasible as it is not possible to guarantee that the hydrogen would not reach the fuel. Either the carbide or oxide of uranium could be used in place of the metal, but in both cases the nuclear properties are worse. The rather obvious point that hydrogen is highly inflammable when mixed with air is probably not such a serious problem as it may first seem, providing that the equipment is well designed. Hydrogen cooling has been successfully used in other applications, such as the cooling of large alternators.

The capture cross-section of hydrogen is sufficiently high to make the use of slightly enriched fuel necessary at moderate and higher temperatures ; the enrichment can be quite low, however. Deep fins could not be used to advantage with hydrogen as the fin efficiency would be very low, so that the primary surface for heat transfer would probably be increased in these cases by " spreading " the fuel across the coolant channel instead of concentrating it. This " spreading " would lower the available reactivity ; for high specific output such " spreading " of the fuel is probably necessary in any case for heat removal, and hydrogen is not necessarily at a disadvantage on this score.

Nitrogen.—Nitrogen has been suggested since it is reasonably inert at moderate temperatures and is readily available. Its neutron capture is high, however, and, as can be seen from the accompanying table, it does not show well on the $M^2C_p^3$ basis for pumping power. Its main use would appear to be in a small, high-temperature reactor in which the materials can be chosen to be compatible with nitrogen and in which enriched fuel is used.

Values of $M^2C_p^3$

	Temperature, deg. Cent.	M	C_p	$M^2C_p^3$
Carbon dioxide	100	44	0·220	20·5
	300		0·253	31·4
	500		0·277	41·0
Helium	100	4	1·242	30·65
	300		1·242	30·65
	500		1·242	30·65
Hydrogen	100	2	3·45	165·0
	300		3·47	167·0
	500		3·50	172·0
Nitrogen (or air, approx.)	100	28	0·249	12·46
	300		0·256	13·18
	500		0·267	14·9

Air.—The oxygen in air is highly reactive chemically, and the nitrogen content has the disadvantages given above. Air can be successfully employed for the cooling of low-power experimental or similar low-flux piles, in open circuits, but not for power-producing reactors.

It will be seen from the foregoing that the gases described are very advantageous for use with natural uranium or fuels with very low enrichments. As the amount of fissile material in the fuel is increased, however, while the merits of gases do not decrease, the advantages of using liquids, including the liquid metals, increase rapidly ; smaller cores, simpler fuel elements, and much smaller and simpler heat exchangers are possible with liquids, due to the vastly increased heat transfer coefficients obtainable. These advantages are usually paid for by a lower neutron economy. When a very-high-temperature coolant is required, however, an inert gas such as helium may still be a good choice, as corrosion is a major problem with liquids under these conditions.

That a gas coolant can be successfully used in a large thermal reactor has been shown by the success of the Calder Hall type ; this design has shown that gas is very suitable for a land-based station of moderate rating, where safe and easy control is required. In fact, since natural uranium is the basic fuel for such reactors, the use of gas is almost obligatory. In spite of its present strong economic position an obvious question springs to mind in connection with the large gas-cooled reactor ; is there much prospect of considerable development of this type or will it be supplanted in the near future by others ? An answer to this can only be given after consideration of many factors, including fuel supplies, the economics of fuel enrichment, fuel recycling, availability of materials, and the particular conditions of the country where it is sited ; only a very few remarks relevant to gas cooling can be given here.

Probably one of the major disadvantages of the present type of gas-cooled graphite pile is its sheer bulk ; the future trend is therefore bound to be a pursuit of higher channel ratings and high specific fuel ratings. Under these conditions it would seem that for the gas-cooled reactor to remain competitive for a reasonably long period, operating temperatures must be high. A high temperature rise in the gas passing through the reactor core results in a large heat output combined with a moderate mass flow ; hence, coolant channels can be small and blower power still not excessive. Fig. 1 shows that higher fuel element temperatures permit

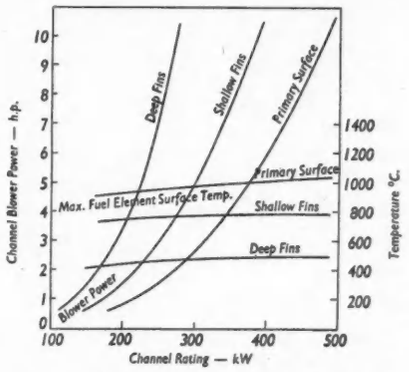

Fig. 1—Graph showing typical relationship between blower power and fuel element temperature with varying channel ratings in same size and length channel

increased channel ratings to be attained without the use of intolerably large blower powers. The high gas outlet temperature allows a sufficiently large temperature difference between gas and steam (or other secondary fluid) to be maintained to permit the use of compact exchangers with simple tubes. Fuel elements capable of running at very high temperatures allow primary surfaces to be used with simple elements.

The future of gas as a coolant may therefore depend on the development of fuel elements capable of withstanding high temperatures, and pressure vessels, ducting and heat exchangers which withstand temperatures considerably higher than the steam temperatures required. Typical figures could be steam temperature of 540 deg. Cent. (1004 deg. Fah.), outlet gas temperature 600 deg. Cent., and fuel element surface 800 deg. Cent.; this latter figure can vary widely, of course, depending on the shape and surface of the fuel elements. A limitation is placed here on the moderator, and it may be necessary to cool it separately.

If these conditions can be met the gas-cooled reactor could be quite attractive for a considerable number of years. In countries where local constructional facilities are poor, and where transport is difficult, their bulk would be a disadvantage. To offset this is the very real advantage that much experience is being gained in the design, construction and operation of such a reactor, and for export a proved design could be offered Probably, for this latter purpose, a gas-cooled reactor, in which simplification of design and control has been highly developed, would be a very powerful competitor to any other type for the next decade or two ; very much depends, of course, on the future costs and

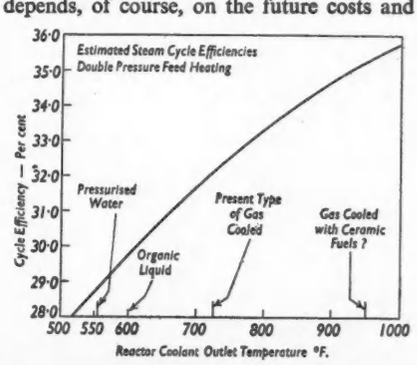

Fig. 2—Estimated variation of steam cycle efficiency with coolant output temperatures, showing probable outlet temperatures for some reactor types

availability of enriched fuel or artificially produced fuels such as plutonium.

In conclusion, it can be seen that the advantages gained by using a gas as coolant are reflected in the economics of the new designs for power-producing reactors to be built in this country. In these reactors, providing the station is large, the capital cost per kilowatt-hour is not excessively high for a base-load station. Again, these reactors offer the lowest cost per kilowatt-hour of electricity sent out of any commercial reactor at present designed. It is these features which allow the nuclear reactor programme in this country to be put in hand immediately.

The development of the gas-cooled reactor has only just started, and it is more than probable that the stage II high-temperature, gas-cooled reactor will not have a large bulk when compared with the liquid-cooled reactor. The high-temperature gas-cooled reactor will also have the very considerable advantage over the liquid-cooled reactor of far higher coolant temperatures ; this means that the thermal efficiency of the steam cycle can approach that used in modern coal-fired stations, as shown in Fig. 2, page 975.

Discharge from an Engine Cylinder to Atmosphere

By R. S. BENSON, M.Sc. (Eng.), A.M.I.Mech.E., A.M.I.Mar.E.*

No. II—(*Concluded from page 949, June 21*)

The discharge of gas from a cylinder to atmosphere in a running engine with variable cylinder length and both outflow and inflow through piston-controlled exhaust ports is analysed by the method of characteristics. The analysis confirms that the mode of discharge is by wave action which persists even after the discharge process is over. An experimental investigation on a running engine is described. The experiments confirmed that the mode of discharge was by wave action which persisted after the discharge was completed. Arising out of the experiments it is concluded that a depression of the magnitude claimed by Kadenacy could be obtained on an engine with no exhaust appurtenances ; these effects can be explained by classical gas dynamic theory. It is, however, concluded that the enhanced performance of engines running on the Kadenacy system is explained by the high rate of port opening associated with large depressions, rather than by the depression itself.

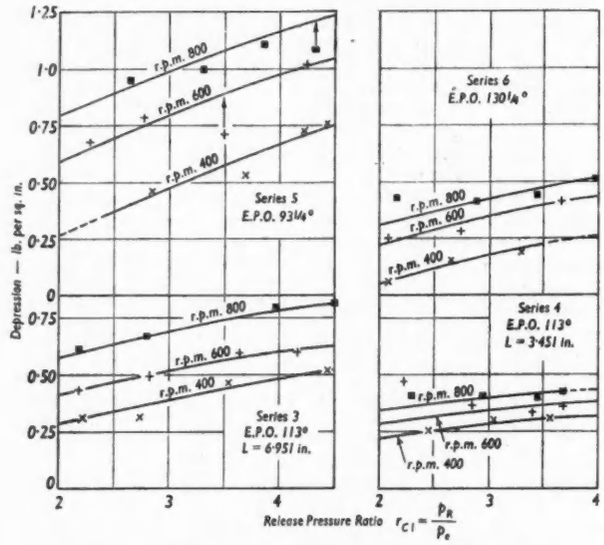
Depression — lb. per sq. in.
Release Pressure Ratio $r_{c1} = \frac{p_R}{p_e}$
Series 5 E.P.O. 93¼°
Series 3 E.P.O. 113° L = 6·951 in.
Series 6 E.P.O. 130¼°
Series 4 E.P.O. 113° L = 3·451 in.
r.p.m. 800
r.p.m. 600
r.p.m. 400

Fig. 10—Experimental results showing four series of depression measurements

2. Test Programme and Results

FIVE series of tests were carried out. Series Nos. 3 and 4 with port opening 113 deg. after top dead centre and cylinder length 6·951in and 3·451in respectively. Series Nos. 5 and 6 with port opening 93¾ deg. and 130¼ deg. after top dead centre respectively and cylinder length 6·951in. (The cylinder length corresponding to the height above the ports.) Series No. 7 with port opening 113 deg. after top dead centre and cylinder length 6·951in, but with one-sixth port area of the other experiments. The port shape and dimensions together with port area crank angle characteristics are given in Fig. 6, *ante*. In each series five speeds were examined, 400–800 r.p.m. in increments of 100 r.p.m. Ten tests at five release pressures were carried out for each speed run, giving in all a total of some 250 tests. In addition, a number of *ad hoc* tests were carried out with indicating at both ends of the cylinder. For the early experiments (Series 3 to 6) only one reliable pressure pick-up was available, and this was used in the cylinder cover. In the analysis which follows these diagrams only were used. A selection of the results for 400, 600 and 800 r.p.m. only are given to reduce space. No observed depression or wave action was noted in Series 7 and indeed for the majority of tests in this series the cylinder pressure did not drop below 1·1 atmospheres absolute.

3. Analysis of Results

(*a*) *Depression Effects.* — The observed depression for each test was referred to a common barometric pressure (15 lb per square inch absolute) and plotted against release pressure ratio r_{c1}, the results being shown in Fig. 10 for Series 3, 4, 5 and 6. Each point is the mean of two tests. As will be seen, the greatest depression occurs in Series 5 (e.p.o. 93¾ deg. L=6·951in) and the least in Series 6 (e.p.o. 130¼ deg. L=6·951in). The comparison of results for two cylinder lengths Series 3 (L=6·951in), Series 4 (L=3·451in) for the same exhaust port timing (113 deg.) shows that the longer cylinder produces the greatest depression. The observed depressions were all smaller than the theoretical values ; this was due to the flow coefficient being assumed to be unity in the theoretical calculation, the flow coefficient would be less than unity and would vary with pressure drop across the ports and with the port geometry. To establish the port area corresponding to value of the depression the following procedure was adopted. It was assumed that the depression was due to the reflection of the expansion wave from the ports, from a knowledge of the speed n, cylinder length L, release pressure ratio r_{c1} and temperature T_{c1}, it was possible to calculate the time in crank angles for an expansion wave to travel from the ports to the closed end. This crank angle was deducted from the crank angle at which the depression was observed. From this derived crank angle the port area ratio was determined. The results are shown in Fig. 11, where the depression in pounds per square inch is plotted against the geometric port area ratio, on the same graph the theoretical curves are shown for flow coefficient (μ) 0·6 and 0·7. The majority of the results are in a band between these coefficients. It should be noted that the value μ will vary with ϕ and with the pressure difference across the ports and a continuous curve should not be expected. The value of ϕ calculated by this method does not differ very much from the value of ϕ at atmospheric pressure. The observed depression for all the experiments are shown plotted against this value of ϕ in Fig. 12. As will be seen this substantially proves the theoretical treatment that the depression is a function of the port area at the end of discharge. Thus the effect

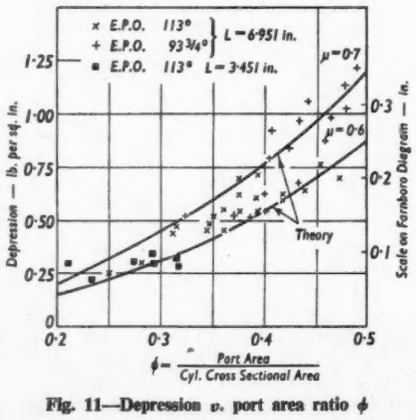
× E.P.O. 113°
+ E.P.O. 93¾°
■ E.P.O. 113° L = 3·451 in.
L = 6·951 in.
μ = 0·7
μ = 0·6
Theory
Depression — lb. per sq. in.
Scale on Farnboro Diagram — in.
$\phi = \frac{\text{Port Area}}{\text{Cyl. Cross Sectional Area}}$

Fig. 11—Depression *v.* port area ratio ϕ

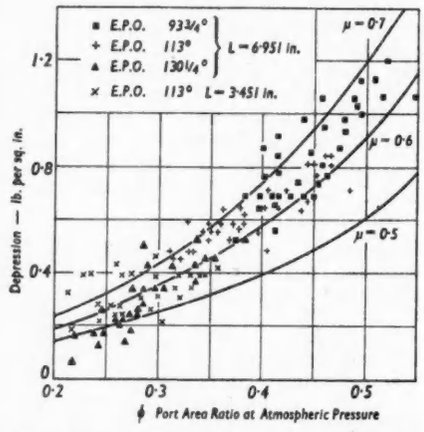
■ E.P.O. 93¾°
+ E.P.O. 113°
▲ E.P.O. 130¼°
× E.P.O. 113° L = 3·451 in.
L = 6·951 in.
μ = 0·7
μ = 0·6
μ = 0·5
Depression — lb. per sq. in.
ϕ Port Area Ratio at Atmospheric Pressure

Fig. 12—Depression *v.* port area ratio at atmospheric pressure

* University of Liverpool.

of the physical variables, i.e. port opening timing, release pressure, cylinder length, &c., on the port area at the end of discharge will give an indication of the magnitude of the depression. In Fig. 13 the observed values

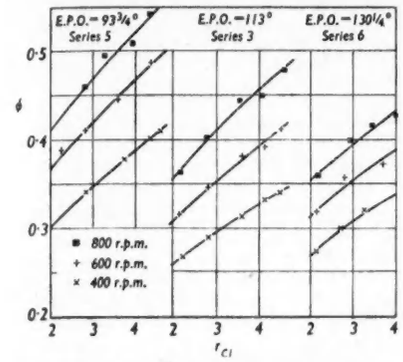

Fig. 13—Port area ratio at atmospheric pressure

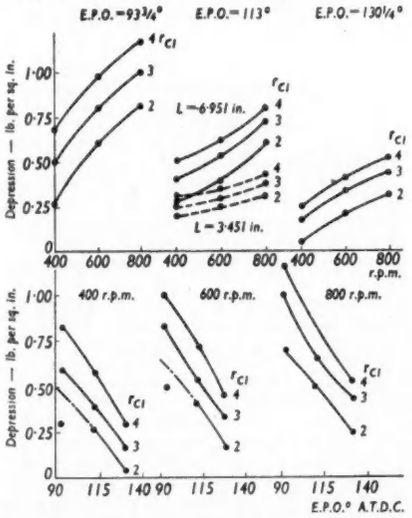

Fig. 14—Variation in depression with E.P.O. and r.p.m.

of ϕ at atmospheric pressure are given for Series 3, 5 and 6.

Arising from the results a series of derived curves are given in Fig. 14. These show the effect of speed, port opening timing, release pressure on the magnitude of the depression. The speed, cylinder length and release temperature can be combined as an "engine number" $\frac{Ln}{\sqrt{T_{c1}}}$, where L is cylinder length at release in feet, n is engine speed in revolutions per minute, and T_{c1} is cylinder release temperature in degrees Fahrenheit absolute. The results for Series 3 and 4 with the same exhaust port timing are shown plotted against this parameter in Fig. 15.

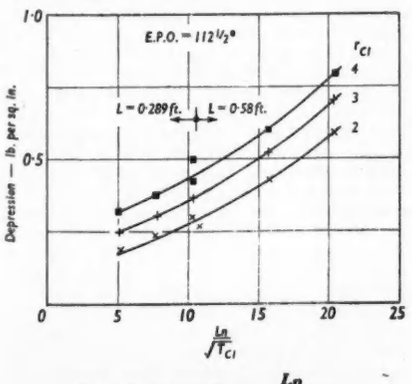

Fig. 15—Depression $v.$ $\frac{Ln}{\sqrt{T_{c1}}}$

Of the same practical importance as the magnitude of the depression is the duration. This will be a function of the release pressure ratio r_{c1} and the "engine number"; the parameter used in this analysis is $\frac{(Ln)}{\sqrt{T_{c1}}} r_{c1}^{1/7}$. The observed duration of the depression is plotted against this parameter for Series 3 and 5 in Fig. 16. The experimental results

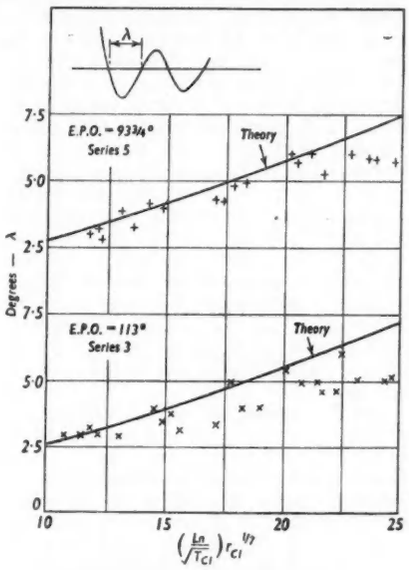

Fig. 16—Duration of depression

agree favourably with the theoretical trend as predicted by the method of characteristics.

(*b*) *Analysis of Post Discharge Wave Action.*—The theoretical treatment indicated that the post discharge wave action was associated with the mode of discharge in the cylinder, the wave action being consequent on the "die away" of the main expansion wave. This analysis was in three parts. A typical indicator diagram was analysed by the theory of characteristics and compared with the observed diagram. Since the boundary conditions were not known, the actual pressure-time diagram at the end of the discharge was taken as the boundary curve; by continuously plotting the state and position diagram the theoretical wave action was calculated. The results are shown in Fig. 17. The cylinder release pressure was 4·0 atmospheres absolute, engine speed 795 r.p.m., the equivalent state diagram obtained from the curves in Fig. 4 was used and the position characteristics were assumed to be straight. It will be seen that there is close agreement between the theoretical and actual diagram. This confirmed that the post discharge wave action was associated with the primary discharge. An analysis was then made of all the tests in Series 3 and 5 and some in Series 4. The basis of the analysis was comparison of the measured wavelength β associated with the first wave in the cylinder with the theoretical wavelength based on the method of characteristics; these results are shown in Fig. 18. The mean wavelengths α for three

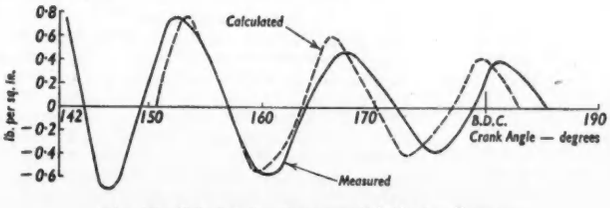

Fig. 17—Calculated and measured indicator diagram

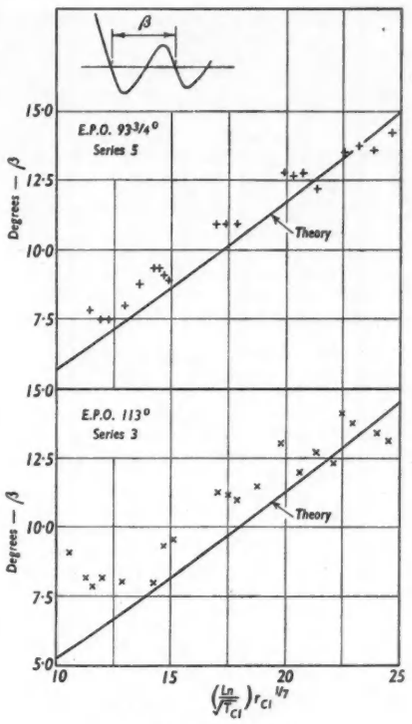

Fig. 18—Wave length β

cycles were also determined and plotted against the parameter $\frac{nr_{c1}^{1/7}}{\sqrt{T_{c1}}}$: these results are shown in Fig. 19. In the case of Fig. 18 the calculated values took into account the varying cylinder volume and hence the parameter used was $\frac{Ln}{\sqrt{T_{c1}}} r_{c1}^{1/7}$. For Fig. 19 a constant cylinder length was assumed, with a speed of sound at release of 1120 f.p.s. Based on these values, the wavelength α was given by :

Series 3 and 5

$$\alpha = \frac{0{\cdot}316 n r_{c1}^{1/7}}{\sqrt{T_{c1}}}.$$

Series 4

$$\alpha = \frac{0{\cdot}158 n r_{c1}^{1/7}}{\sqrt{T_{c1}}}.$$

Assuming a linear variation between α and $\frac{nr_{c1}^{1/7}}{\sqrt{T_{c1}}}$, the derived results from Fig. 19 were :

Series 3

$$\alpha = 0{\cdot}325 \frac{nr_{c1}^{1/7}}{\sqrt{T_{c1}}} + 1{\cdot}1.$$

Series 4

$$\alpha = 0{\cdot}175 \frac{nr_{c1}^{1/7}}{\sqrt{T_{c1}}} + 1{\cdot}2.$$

Series 5

$$\alpha = 0{\cdot}333 \frac{nr_{c1}^{1/7}}{\sqrt{T_{c1}}} + 1{\cdot}2.$$

The deviation from theory is probably due to the assumptions made, viz., constant cylinder length and speed of sound. Nevertheless, there is very good agreement between the theory and experiments.

These experiments, therefore, confirm the

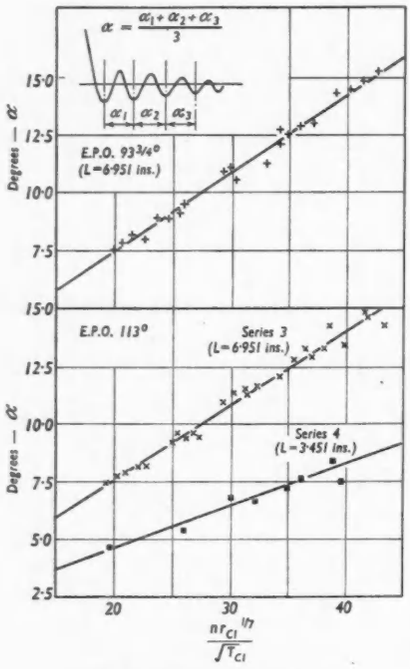

Fig. 19—Mean wave length α.

theoretical analysis, that there can be wave action in the cylinder even with no exhaust belt or pipe and that the mode of discharge is by wave action.

Discussion and Conclusions

The experiments demonstrate that the mode of discharge from a cylinder to atmosphere in a running engine with exhaust ports of standard design is by wave action. Furthermore, the wave action persists even after the primary discharge is over. Thus, the Kadenacy effect can be explained by classical gas dynamic theory. The question is raised : are the depression effects of sufficient magnitude to justify the claims made by designers of engines operating on Kadenacy patents ? From the experiments and the theoretical treatment discussed here, it is well-established that large depressions may be obtained, but in general the durations of these depressions are very short and not sufficiently long by themselves for the advantages claimed to be obtained. The question is then raised : how are the improved performances obtained with these engines to be explained ? In general all the engines operate with exhaust belts, pipes and some with diffusers or ejectors. All these devices increase the magnitude and duration of the depression. The theory associated with the exhaust system external to the cylinder has been very thoroughly examined by Mucklow, Bannister[3] Wallace,[5] Mitchell,[5] Nassif,[6] Boxer,[7] and again this is based on classical theory. It may again be argued that nearly all engines have these appurtenances and yet do not have the performance of a Kadenacy engine. This is to be doubted and is probably due to bad exhaust pipe design. Nevertheless, the advantages of the Kadenacy system cannot be completely explained away by this premise. The probable explanation is associated with the depression phenomenon discussed above.

All Kadenacy engines run with a blower. The rapid port opening required to produce the large port area ratios at the end of discharge and, hence, the large observed depressions, also produce high particle velocities in the cylinder. The exhaust gas stream is, therefore, leaving the cylinder with a high velocity when the scavenge ports open. The incoming scavenge air has, therefore, only to overcome the resistance of the stationary gas particles at the closed end adjacent to the scavenge port. Furthermore, the opening at the port end of the cylinder does not reduce the wave action to a great extent, since the cold air layer adjacent to the hot gases acts as a closed end;[8] thus the pressure waves are still reflected at this point. The negative or expansion waves reduce the pressure ahead of the cold gas column, thus further reducing the resistance. Hence, the wave action in the cylinder enhances the scavenge process. The net result is to reduce the scavenge pressure for a given volume of air supply, hence the scavenge pump horsepower is reduced and the overall engine efficiency improves. By admitting cold air into the cylinder the effective cylinder length of the hot gases is reduced and the scavenge process is completed with the minimum resistance. Indeed, it would be anticipated that a pressure difference might exist across the cylinder, but it would be necessary to produce a detailed calculation to check this point. With these high rates of port opening there would probably be only a limited amount of diffusion at the boundary of the hot and cold gas layer.

Thus, from this analysis one can deduce that the enhanced performance of engines operating on Kadenacy patents is not due to the direct effect of the depression in the cylinder, since the duration is too short, but to the high rate of port opening associated with these depression effects. Thus it appears that the problem is essentially a mechanical one, the phenomenon in the cylinder being explained entirely by classical gas dynamics. In order to facilitate maximum port opening the designer must consider port timing, port shape and design. In addition, a knowledge of the appropriate flow coefficient is necessary. The greater the port area, the greater the depression and, hence, *ipso facto*, the greater the gas velocities in the cylinder and lower gas resistance. All these factors increase the overall scavenge efficiency. The calculation of the port areas can be carried out by the normal methods and requires no special knowledge.[1, 9]

Acknowledgments

The author wishes to acknowledge with thanks the help and facilities given by Professor W. J. Kearton, Harrison Professor of Mechanical Engineering, University of Liverpool, to carry out the experiments in the Walker and Harrison-Hughes Engineering Laboratories of the University.

The author wishes to acknowledge with thanks the help and advice given by Mr. W. Miller, Superintendent of the Laboratories, and his staff.

Finally, the author wishes to acknowledge with thanks the loan of certain of the indicator equipment by the British Shipbuilding Research Association.

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Technical Progress in Steam Turbine Design

At the British Electrical Power Convention, Eastbourne, last week, Mr. L. S. Robson presented, on behalf of BEAMA, a paper entitled "The Contribution of the Turbo-Alternator Manufacturers to Technical Advancement and to the National Economy." In this paper the author outlined some of the considerations involved in the design of turbo-generator plant and commented on technical advances made in this field. Abstracts from the author's remarks on steam turbine design are reproduced here.*

Steam Conditions and Output.—In general terms, the maximum output for which a turbine can be designed is limited by the quantity of steam that can be passed through the final stage blading with an acceptable leaving loss. The table shows the conditions adopted for certain C.E.A. standard 3000 r.p.m. turbines ; the increase in available heat drop due to raising the initial steam conditions and reheating; and relative steam rates to turbine and condenser per unit generated. It will be observed that increased feed heating with more advanced conditions materially affects the steam quantity to the condenser.

The table shows also the relative output obtainable at the stated conditions for a given last row annulus and a constant percentage leaving loss. It will be seen that 2350 lb per square inch gauge, 1050/1000 deg. Fah., permits an increase in output of some 83 per cent relative to 600 lb per square inch gauge, 850 deg. Fah. It must be emphasised that the comparison remains valid only so long as unit size is suitable for the higher conditions.

When units of small capacity are designed for the higher conditions, the greater available heat drop reduces the required mass flow, and, consequently, the blade heights at the inlet end. Losses associated with short blades, together with the proportionately greater mechanical, gland and other leakage losses, can drastically reduce any theoretical advantage. In this respect, it may be remarked that a secondary benefit of bled steam feed heating is that it increases blade heights at the high-pressure end.

The Final Stage Blade.—On the basis of the table it would appear that a last blade designed for 60MW in double flow under 900 lb per square inch gauge, 900 deg. Fah. conditions would give 30MW in single flow at 900 lb per square inch gauge, 900 deg. Fah.; but it would need to be in triple flow for both 100MW (109·5) at 1500 lb per square inch gauge, 1050 deg. Fah., and 120MW (124·2) at 1500 lb per square inch gauge, 1000/1000 deg. Fah.; and it might not be acceptable in quadruple flow for 200MW (189·4) at 2350 lb per square inch gauge, 1050/1000 deg. Fah.—the respective relative outputs being in parentheses.† Similarly, a last blade designed for 120MW in double flow for 1500 lb per square inch gauge, 1000/1000 deg. Fah., would be equally suitable in double flow for 100MW at 1500 lb per square inch gauge, 1050 deg. Fah.; in triple flow for 200MW at 2350 lb per square inch gauge, 1050/1000 deg. Fah.; and in quadruple flow for 275MW at 2300 lb per square inch gauge,

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† An exhaust giving 30MW at 900 lb per square inch gauge, 900 deg. Fah., would give 160÷116×30=44·4MW at 1500 lb per square inch gauge, 1000/1000 deg. Fah.

Comparison of Steam Cycles
(C.E.A standards)

1	Stop valve pressure, pounds per square inch gauge	600	900	1500	1500	2350	2300	2300
2	Stop valve temperature, degrees Fahrenheit	850	900	1050	1000	1050	1050	1050
3	Reheat temperature, degrees Fahrenheit	—	—	—	1000	1000	1050	1050
4	Vacuum, in Hg.	28·9	28·9	28·9	28·9	28·9	28·9	28·9
5	Temperature leaving final heater, degrees Fahrenheit ...	330	385	400	435	460	486	486
6	Number of feed heating stages	4	5	6	6	7	7	7
7	Relative available heat drop per pound of steam to stop valve,* per cent	100	102·9	117·5	126·3	131·4	129·8	129·8
8	Relative steam to stop valve per megawatt, per cent... ...	100	96·6	85·9	77·3	75·1	74·8	74·1
9	Steam to condenser relative to steam to stop valve, per cent	78·0	73·7	72·7	70·7	67·4	66·5	66·5
10	Relative steam to condenser per megawatt, per cent... ...	100	91·2	79·7	79·0	64·8	63·7	63·1
11	Relative specific volume at 28·9in Hg., per cent	100	98·7	99·3	105·8	104·6	104·0	104·0
12	Relative output for constant annulus and constant leaving velocity, per cent	100	111	126	135	148	151	153
13	Relative output for constant annulus and constant percentage leaving loss, per cent	100	116	141	160	183	187	189

* Weighted for feed heating. Reheat pressures are not a constant percentage of initial pressure.

1050/1050 deg. Fah. Two such blades could reasonably cover the present range of outputs: the annulus ratio would be approximately 1 : 1·5.

The development of a new last blade is a major undertaking. As the blade height is appreciable compared with the mean diameter, the variation of blade pitch from root to tip is considerable, and this, coupled with the necessary taper to reduce centrifugal stresses, leads to difficulties in providing a suitable steam path at root and tip as well as at the mean diameter. The blade must be twisted to give suitable inlet and outlet angles along its length, and, to reduce bending stresses due to centrifugal pull, the locus of the centre of gravity of the section should approximate to a straight line. These simultaneous requirements produce a design problem of some magnitude.

Such a new blade should provide a leaving area appreciably greater than its predecessors—preferably about 50 per cent greater. It should, therefore, have a greater length or mean diameter, or both, and must be designed to carry the consequent increase in centrifugal pull. Strength in bending must be ample, vibration characteristics must be such as to avoid trouble over the expected life, and the blade profile from root to tip should give efficiencies of a high order. The leading edge must be protected against erosion; the method of attachment requires careful study, and, finally, the disc to which it is to be attached must be suitably designed.

A new last blade embodies the accumulated experience of its forerunners. Before it is adopted for manufacture, it is the subject of rigorous analysis and testing. This includes testing of full-scale models of the blade root fastening for strength; wind tunnel testing of typical blade sections for efficiency; full-scale testing of finished blades for vibration characteristics, both individually and in groups, and overspeed testing of a fully bladed disc. Thus, its development absorbs a formidable total of engineering man-hours, and its introduction represents a considerable capital investment by the manufacturer. This can be liquidated only by using it in single or multiple exhaust flows in a large number of machines. Consequently, the leaving areas available to the designer vary in relatively large steps that form the bases of a series of frames for given ranges in output. Finally, maximum utilisation demands that a given blade shall be suitable for variations in mass flow arising from differences in steam conditions and vacua: the criterion is the acceptable leaving loss.

Progress in the art may be typified by stating that one manufacturer who employed a given blade in double flow for 30MW has produced another which could be used in quadruple flow for 275MW, both at 3000 r.p.m. The single annuli are in the ratio 1 : 2·87; the tip speeds are 877ft and 1440ft per second respectively, and the centrifugal pull of a single blade has increased from 7·7 tons to 44·5 tons.

At the larger ratings, tip speeds tend to be of the order of 1400ft per second, a velocity in the region of that of sound in steam at the relevant conditions. This general increase in tip speeds indicates that while skilful design has provided longer blades, the relatively smaller increase in stresses is well within the improvement in constructional materials.

Low-Pressure Rotors.—Low-pressure rotor construction varies from manufacturer to manufacturer. Separate discs for the final stage are usually of 3 per cent chromium, 0·5 per cent molybdenum, steel with ultimate tensile strengths and yield points of 55 and 45 tons per square inch respectively. Where solid rotors with integral discs are employed, the construction permits 45/35-ton, 3 per cent chromium, 0·5 per cent molybdenum steels, and it should be borne in mind that such rotor forgings begin as 100-ton ingots. There has been an increasing demand for large forgings with properties consistent throughout the mass of the material, and this has led to the development of improved inspection and testing techniques. In particular, there has been considerable advance in non-destructive testing, especially in ultra-sonic methods.

Materials for High Temperatures.—Design for high operating temperatures is still conditioned by the limitations imposed by materials of construction. Large-scale investigations in both laboratories and power stations continue.

As a very brief summary of the present situation, Dollin may be quoted: "When steels are required to withstand stress and oxidation for long times at temperatures above 1050 deg. Fah., it is generally considered necessary at the present time to use austenitic steel of the 18 per cent chromium, 12 per cent nickel and 1 per cent niobium type. There are, however, serious objections to the use of austenitic steels. They are expensive, difficult to cast and forge and not easy to machine. They have a low yield point at room temperature, a high coefficient of expansion which gives rise to big movements or forces and makes the control of clearances difficult, and a low thermal conductivity which, in conjunction with the high coefficient of expansion, gives rise to high thermal stresses. Because of these difficulties much attention is now being given to the development of 6 per cent and 12 per cent chromium ferritic steels alloyed with such elements as titanium, vanadium and niobium to give high creep resistance. It is hoped that in this way the temperature at which it becomes necessary to use austenitic steels can be raised to 1150 deg. Fah."

For operating temperatures of 1050 deg. Fah., low alloy molybdenum-vanadium and chrome-molybdenum-vanadium steels are current practice.

Casings for High Pressures and High Temperatures.—Double-shell casings are almost universally employed for the high-pressure cylinders of machines of the largest capacities, and some manufacturers also employ this construction for machines of 100MW and 120MW. Double-shell construction is adopted to a lesser extent for the inlet ends of intermediate-pressure cylinders which receive steam from the reheater.

Double-shell construction has the advantage that establishing intermediate pressures and temperatures between shells limits pressure and temperature gradients across the individual casings. Thus, each casing may be of lighter construction than for a single shell. The heating up of the casing metal at starting is facilitated, and inner and outer shells may be of materials suited to their operating conditions. The design is, of course, a little more complicated: to accommodate differences in expansion, steam inlet pipes passing through the outer shell must be permitted a degree of freedom, as may be provided, for example, by piston ring seals, where the pipes enter the inner shell.

With inserted nozzle boxes, which are also commonly employed for high pressures and temperatures, the pressure and temperature to which the casing is exposed is limited to that after the first stage.

Castings are now frequently used where forgings were formerly considered essential. As a result of close collaboration with the steel founders, steel castings for steam turbines are no longer suspect from the viewpoint of reliability in service. Comprehensive non-destructive methods of examination have been developed and are now common practice; and the rectification of castings by welding under the control of a metallurgist is now equally acceptable to the turbine manufacturer and his customer.

So far, double-shell construction has not been adopted for steam chests and steam piping because of the complications involved, although the conditions of operation are similar to those at the turbine inlet. Steam chests for temperatures above 1000 deg. Fah. are almost invariably machined from solid forgings: steam pipe materials and methods of welding are constantly under review.

Reheating: a Problem in Design.—The widespread reintroduction of the reheat cycle has been responsible for some interesting problems in design. The readmission of high-temperature steam, for example, has a direct effect on the design of intermediate-pressure cylinders of large reheat machines. At the inlet, both casing and rotor may be subject to almost the full reheat temperature: at the exhaust end, where temperatures are more moderate, the blade lengths may be appreciable, and the rotor material must have good physical properties to deal with the centrifugal stresses involved.

There are several ways of dealing with this problem. Inserted nozzle boxes could be used at the inlet, and a first stage with a large heat drop and a two-row velocity wheel would reduce the temperature in the cylinder to reasonable proportions, although there would be a slight loss of efficiency. Alternatively, inserted nozzle boxes with a smaller heat drop could be used if the rotor were made of high-temperature material, but separate shrunk-on discs of high-tensile material would be required if the cylinder incorporated one of the exhaust flows. A further alternative offers distinct advantages, but results in some slight complication of the high-pressure casing. The reheated steam could be expanded in stages housed in the high-pressure cylinder before it passed, at moderate temperature, to the intermediate-pressure cylinder, where an integral rotor could be of material suited to the longest blades. This solution also simplifies the design of the interceptor chests which are located between the cylinders, and which are also subjected to moderate temperatures only.

Turbine Rotors.—Quite apart from considerations already outlined, the turbine rotor, its construction and behaviour, is a major engineering study. The accumulation of experience, often by extensive testing, is an important adjunct to design. Materials and methods, as well as the design of associated components, are continually under review.

Thermal distortion related analytically to the effect of shrunk-on gland sleeves has already led to the virtual abandonment of this type of construction for rotors exposed to high temperatures. Similar considerations and background of experience have led to the widespread adoption of the integral disc construction where this is applicable.

Statistically, experience indicates that, with rotors of built-up construction, there is almost always some slight distortion after protracted service, and the distortion increases with temperature for a given time, and with time for a given temperature. With purely low-temperature rotors, the condition is of no operational significance, since the distortion is always small, and even after long service seldom requires more than normal rebalancing when the rotor is returned to the manufacturer for normal servicing or overhaul.

It is current practice to stabilise integral rotors by lathe-oven treatment as a normal process of manufacture. This is a desirable and effective safeguard against thermal instability despite its

extreme rarity, or absence, in operational experience : it does not, however, prevent bending due to transient thermal gradients arising from the conditions of operation. The intelligent use of supervisory equipment, and adequate barring at shut-down and particularly before starting, are the answers to this problem.

Field study, while it has done so much to increase the knowledge of the designer, has also introduced fresh problems for analytical investigation. Elce records an example of a rotor operating satisfactorily with an indicated eccentricity at mid-length that would seem to make it impossible to run without severe vibration. Tests involving the measurement of the simultaneous deflection of the shaft at both ends, both in magnitude and direction (Fig. 1) indicated

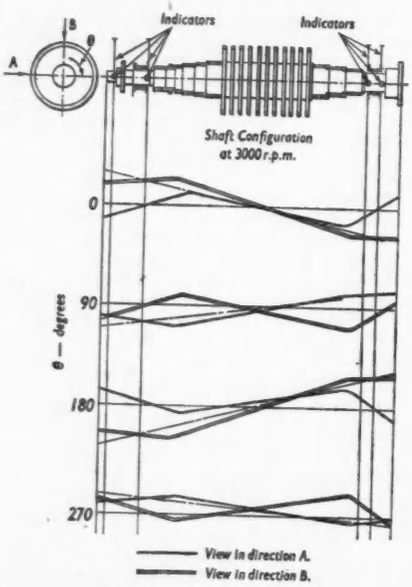


Fig. 1—Deformation of a steam turbine rotor

that the shaft configuration was complex, that the centre of mass was virtually undisturbed, and that distortion was in the region of the glands. It was, possibly, associated with gland sleeve effects, but there are many branches of investigation that may stem from the observation of similar phenomena. The effects of critical speeds of rigidly coupled rotor systems supported in various manners, the influence of bearing clearances, the problems of oil film whirl, and other resonances, are examples.

Two-Shift Operation.—Considerable study has been devoted to the development of rapid starting techniques for two-shift operation in association with both unit and range-connected boilers. Factors affecting the rate of starting are the relative steam and turbine metal temperatures, which vary according to the length of the shut-down period, and the thermal stresses and differences in expansion of rotors and casings. It is only during recent years with the advances in operating conditions that such a requirement has become a serious problem ; equally, the prospect of base-load nuclear stations in the future emphasises the need. Adequate supervisory equipment is, of course, essential.

In the future, with a greater proportion of new plant in service, rapid starting techniques will materially improve the overall thermal efficiency of generation. Past practice, and the shortage of modern plant, has demanded that relatively old machines must be maintained in operation at widely varying load factors, and even as a spinning reserve. In Fig. 2 the author reproduces a curve published by Sir Leonard Pearce in 1940. The curve, which has been extended, gives a correction to be applied to the thermal efficiency of a station operating at its designed conditions to indicate the average thermal efficiency that might be expected in normal operation. It was stated that the curve was a generalisation, being the mean of a number of plotted points derived from examination of the performances of a large number of stations over an extended period of time, and it could not

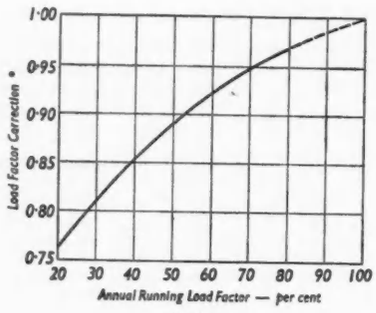


Fig. 2—Correction to station thermal efficiency for variation in annual load factor

be considered accurate to more than 1 or 2 per cent. It may be inferred from the curve that annual load factors in the range of 50 to 70 per cent cause a reduction in station thermal efficiencies of between 10 and 5 per cent. It is reasonable to suppose that, in the future, with rapid starting and block loading, units will operate at maximum economic rating, and station efficiencies will therefore approximate more closely to the design figures. In terms of high efficiency units of large output, this may well lead to a considerable economy in fuel.

Governing and Control Systems.—The advance to higher steam conditions, and the more widespread reintroduction of the reheat cycle, with the consequent increase in complexity, have resulted in intensive development and improvement of governor systems, and refinements in the design of valves and control mechanisms. Equally, the capital investment represented by large modern units, and the need to maintain them in service with the least possible interruption or likelihood of damage due to fortuitous circumstances, has led to the introduction of comprehensive auxiliary controls and safeguards. They are now common practice, and there is no need to discuss them at length. More recently, however, there has been an extension of the practice to include the on-load testing of various safeguarding mechanisms and controls. This is an important feature. It ensures that a suitable operational routine can reasonably guarantee the machine, and the station staff, against the failure of a little-used safety device.

A corollary of this development in controls is the extension of remote operation. Remote control, or push-button starting, of large units is immediately practicable, and centralised operation and supervision is in immediate prospect. This is not to suggest that fully automatic operation of large power stations is more than a future possibility, but the trend can be observed. It follows that the increase in size and complexity of units, and the growth of station capacities, do not necessarily imply a corresponding increase in operational staff. One recurrent trend to be observed in design is the conservation of manpower.

Research

Research within the industry, either by individual manufacturing organisations or in concert with appropriate outside bodies, is a subject sufficiently broad in scope to justify one or several papers of its own. For the turbine alone, to list all branches of investigation would be formidable. Normal laboratory equipment concerned solely with one aspect of turbine design, that of blading efficiency, includes high-speed, low-speed and variable-density wind tunnels, air turbines, single-stage and multi-stage steam turbines, as well as various specialised apparatus for investigating particular aspects of blade and nozzle design and performance. Not least in importance is the concept, design and application of equipment and instruments.

There is, however, one branch of research that must be mentioned—it is of fundamental importance. Lord Kelvin's dictum " to measure is to know," is nowhere more applicable than to the properties of steam at high pressures and temperatures. Turbines are already under construction for temperatures exceeding 1050 deg. Fah. The Keenan and Keyes tables, which extend to 1600 deg. Fah., are based on the extrapolation of data obtained at relatively low temperatures, and give figures differing from those at the upper end of the existing Callendar tables, which go no higher than 1000 deg. Fah. Thus, the starting point of design is in *terra incognita*.

The differences arising from the use of data from various sources may be small quantitatively, but their effect may be significant commercially in computing or comparing high-pressure, high-temperature cycles and the capitalised values of the expected savings.

Independent investigation of the properties of steam carried on in various countries is periodically correlated on an international basis. In Great Britain, the electrical industry, through B.E.A.I.R.A., has been prominent in the support of the investigations now carried out under the direction of Professor D. M. Newitt, F.R.S., at the Imperial College of Science and Technology. Apparatus for accurate measurement of the total heat of steam at pressures up to 6000 lb per square inch gauge and temperatures up to 1400 deg. Fah., has been designed, built and calibrated. The early publication of a new steam table and chart extending at least up to 1200 deg. Fah. is a matter of urgency.

Steam Turbines for Nuclear Power Stations

No paper of this nature could be considered complete without at least a passing reference to turbine-generator units for nuclear power installations. Nuclear plant in general will be fully discussed elsewhere, but it is reasonable to consider a few of the implications.

At the present state of development, appropriate components of large conventional plant may be applied with equal validity. Generator design poses no significant problems ; heat exchange practice is similarly applicable to the generating unit auxiliaries, and the turbine may well adapt existing low-pressure cylinders with the minimum of modification.

The problems of turbine design may be considered as less exacting than with large conventional plant, and the background of experience with moderate pressures and temperatures is considerable. There are, however, some points to consider :

(i) The low initial steam conditions presuppose a low heat drop, a considerable degree of wetness in many stages of the expansion, and a proportionately large steam flow for a given output.

(ii) The more efficient high-pressure staging will form a smaller proportion of the whole, but while the greater specific volume of the inlet steam demands larger pipes and valves, it also requires correspondingly greater blade heights, and the high-pressure stages will be relatively more efficient.

(iii) Mixed-pressure operation leads to some complication of the high-pressure turbine. It requires extra steam chests, containing valves of large size, and the development of suitable valve gear and governing mechanisms.

(iv) Because of the small available heat drop, the leaving loss must be kept down by restricting the steam velocity through the final stage. Even moderate ratings—by conventional standards—may require duplication of the exhaust flows or the development of longer blades.

(v) Despite the low conditions, it is the author's opinion that blade erosion will not be serious : modern methods of stage drainage are more effective as the wetness increases, and it is now established practice to fit protective strips to the leading edges of exhaust blading.

Automatic Gear Changing on Diesel Railcars.—We are informed by Self-Changing Gears, Ltd., Lythalls Lane, Coventry, that a railcar fitted with the " V.S." automatic control has been placed in service on British Railways. This control is used with the " Wilson " gearbox and changes gear automatically to follow a pattern which gives optimum performance from a vehicle. The general principle of the gear was described in our issue of October 5, 1956, dealing with the exhibits at the Commercial Motor Show. Conversion sets of these control gears are now also being made for fitting to Leyland vehicles with a semi-automatic Pneumo-Cyclic gearbox to adapt them for fully automatic transmission.

Farming Machinery a Century Ago

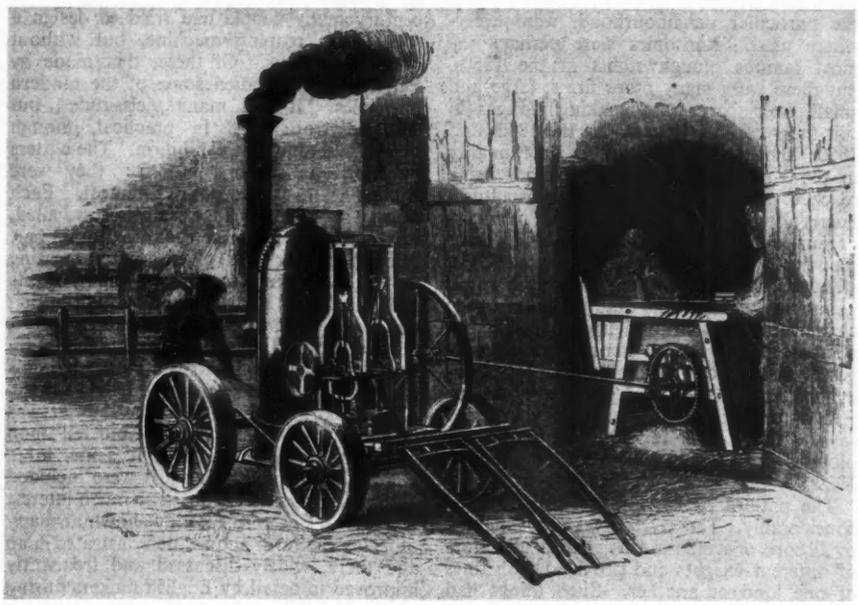
By G. E. FUSSELL, F.R.Hist.S.

Next week, the Royal Agricultural Society's annual show is to be held at Norwich. The display of modern machinery and implements which occupies a large portion of the showground never fails to emphasise the rapid progress of mechanised farming. But it also invokes recollection of the equipment used in past years. Some of the machines which were coming into use in the mid-nineteenth century are reviewed here.

A CENTURY ago mechanical power performed few operations on the farm. Horse, wind and water were the driving force, or sheer weight of beef and brawn in manual operations. Steam power was what everybody was looking forward to ; already it had been used for driving the threshing machine and the numerous grinding, crushing, kibbling and chaff-cutting machines used in a well-equipped barn. " Steam power as applied to agriculture," wrote Robert Ritchie, " is yet in its infancy, but with a prospect of gigantic manhood before it. It seems fitted in all probability . . . to effect great changes in farm operations, and to give the same impetus to agriculture, which it has done to all branches of the arts." Electromagnetism, too, had then recently been suggested as another possible source of power for driving barn machinery, but Ritchie was not satisfied with the experiments that had been made with " galvanism." Little that was of practical use had developed, and the power obtained was small in proportion to its cost. The electrical age was in the future, and Ritchie could not, of course, foresee the grid and the use of many thousand electric motors on the farms.

During the first half of the nineteenth century several steam engines were installed to drive threshing machines, which had been designed nearly a hundred years before, and pretty well perfected by the 1850s. A steam engine was set up to drive one in East Lothian as early as 1812 ; another was on a Berwickshire farm about 1823, and its owner told Ritchie that there were then one or two more in the county. Two years later there were some excellent threshing mills on Lord Stafford's estates in Shropshire. These seem to have been stationary engines. A self-propelling engine for driving a portable threshing set had been made, and was hired out by Grey of Dilston to the Greenwich Hospital estates in Northumberland. In England it was only the northern and Border counties that had so far adopted steam power for threshing. As an example of conditions, three-fourths of the wheat grown in Dorset, " one of the first counties in the south of England," was threshed by horse or water power, and the local maltsters preferred barley threshed by the flail. The *Norfolk Chronicle* of October, 1847, was first to report a new feature in the annals of agriculture ; it had recently seen a steam portable threshing engine at work, and was so impressed as to believe it would rank amongst the most important of modern inventions. This machine, the portable steam engine, had met with similar approbation at agricultural meetings and at the annual shows of the great societies. Portable engines were then generally only of 2 h.p. to 4 h.p., mounted on a neat iron carriage, and could be hauled by one or two horses, though why it did not occur to the inventors to make the things self-propelling is a mystery! These engines (one is illustrated herewith) were considered particularly suitable for small farms. Some landlords thought them unpoetic and objected to them on this rather fastidious and unreasonable ground ; other opinion held them dangerous as possible fire-raising apparatus ; but both gave way before economic necessity and practical experience. But some agricultural societies took a larger view of the possibilities and were offering large premiums, usually sums of money, for the first successful application of steam power to tillage. Ritchie did not think this likely for a good many years but agreed that " the numerous difficulties which have been hitherto experienced may, perhaps in time, be overcome, and ultimately realise the opinion of a sanguine writer that the steam engine of the barn may become applicable to general cultivation." A few years later the Royal Agricultural Society was able to make an award to John Fowler for a system of steam ploughing. Fowler had earlier applied it to hauling a mole plough and pipes for drainage.

Even for driving barn machinery, steam power had only been used in a limited way in 1849. It had been applied to " bruising " grain, chopping hay, slicing turnips, grinding rape, working a butter churn, and driving circular saws. Where the steam engine and thresher were a fixed installation, by a piece of bad construction these " subordinate " machines could usually only be used when the threshing mill shaft was set going. This was because the axle or shaft of the engine connected the power first with the mill. Ritchie very reasonably criticised this arrangement and recommended that the threshing machine should either be worked at the same time or that it should be possible for it to be thrown out of gear. Such arrangements, though involving rather more capital outlay, were not uncommon in the Lothians. One example was a farm in the West of Scotland which had an 8 h.p. high-pressure engine, " the crank shaft conveying the power directly to the threshing machine. A shaft about 50ft or 60ft in length, driven by the engine, passes directly through the barn under the floor of the loft, supported upon wall brackets, which shaft, by means of belts and pulleys, drives a straw cutter placed on the ground floor and a corn and bean bruiser on the floor above ; and there is ample space for placing other machines. The shaft terminates in a clean, well-aired dairy. The steam power, by means of a belt and cranks and levers, is made to work two butter churns upon the plan of the old upright barrels with long handles. . . ." The machines installed in some farmers' barns a century ago were often quite numerous. One had a corn and bean bruiser, straw-cutting machine, hay cutter, turnip slicer, potato slicer and washer, flour and marl stones, rape-cake and guano mill, circular saw, force pump and elevators. Another was even more elaborate : it contained all these except the force-pump, and both the flour and meal stones and the rape-cake and guano mill had each a separate entrance from a separate court. Here, too, were a bone-mill with separate entrance, linseed bruising stones, lifting apparatus, turning lathes, butter churn and " steam apparatus for cattle," which was probably for heating cattle food. A corn-drying loft was arranged over the steam boiler.



Portable steam engine driving a barn threshing machine (*circa* 1845)

The threshing machines, sometimes driven by steam in the 1850s, were of two kinds, those fitted with a beater drum and those with a peg drum. The former was sometimes known as the common Scotch threshing machine. Few of these machines cleaned the corn and separate seed dressers and winnowers had to be used. Many of these were made by Cooch and Son, a firm founded in the year 1800. Eventually, the two processes were combined, and Charles Burrell and Sons, Ltd., of Thetford, made the first combined threshing and dressing machine in 1848 ; it was awarded a prize at the Royal Show at York. The principle was soon adopted by other makers, who were quite numerous, although not all farmers of the

day always wanted the combined machines.

The steam engines used in agriculture in the 1850s were portables. The use of steam traction for haulage did not come until a little later, but it was the railway age. One major enthusiast envisaged a system of railway lines running to every field in the country. "All farms will in a few years have a railway laid from the homestead through the lands I have not the least doubt," and he rightly remarked that carting manure was one of the heaviest jobs on the farm. Farm railways would also be useful for bringing home the harvest. If they were of standard gauge why should not branch lines be constructed from the railways to the farms along the sides of the roads or on any other convenient plan? The farmer would then be able to get a truck from the head of his field on to the main line of railway and thus carry it to a near or distant market without the trouble and expense of frequent shifting. The fanatic declared that the railway system of the country was not half developed until there were railways instead of parish roads, instead of green lanes, and instead of the road at the field's head. Fortunately, perhaps, this state of development was not reached.

Tillage Implements

In plough design there was great variety, and local patterns, said to be the best for the particular neighbourhood, were everywhere used. Ransomes were perhaps the most famous ploughwrights in the 1850s, but there were many other firms, large and small, over the country making ploughs to suit their local customers. In the 1840s and 1850s the theorists admitted that finality in plough design was very far from being reached. As soon as the Royal Agricultural Society was formed (in 1839) members organised trials of the draught of different ploughs. Philip Pusey thought that if a standard plough could be produced it would be possible to use "the draught gauge in the classification of soils to register their different degrees of tenacity." Henry Hannan suggested that all farmers should make dynamometer tests of their ploughs in the various soils on their farms, and while doing different jobs. There were far too many different ploughs in use, and still in use as lately as 1939!

The pattern of harrows used also varied considerably. The harrow was supplemented by all sorts of scufflers, extirpators, cultivators of different weights and provided with tines of one kind or another. Such things had been numerous in the eighteenth century; in the first half of the nineteenth they suffered no diminution. The Ducie grubber, Biddell's extirpator, the Parmenter harrows were some of them. The roller, too, had been developed, the Cambridge roller and Crosskill's clod crusher being only two amongst many. The art of preparing the seed bed had been mechanised so far as it could be with only horsepower draught. A century and a half before, Jethro Tull had designed the first English seed drill that worked. During the interval dozens of designs had been produced, and the general principles had almost been standardised. Early in the nineteenth century James Smyth had set up at Peasenhall, Richard Garrett at Leiston, both in Suffolk. Knapp of Clanfield, Kell of Gloucester, Ransomes of Ipswich, and many others entered into this business between 1800 and 1850. It had taken a century and a half for these machines to come into general use, and by the 1850s the main features of the modern design had been firmly established. The coulters were each fixed to an independent lever for ready adjustment to different widths, and swing steerage enabled the driver to move the coulters to the left or right to keep the line of sowing straight. Most drills were fitted with flexible feeds made of jointed tin tubes held in position by chains, allowing play to meet irregularities. These were not invariably perfect in delivering the seed, for occasionally it was caught when the tubes jerked, and was not sown with absolute regularity. Hornsby overcame this difficulty by using indiarubber tubes; Garrett increased the depth of overlap in the cups in their telescopic tubes, and other makers adopted rather similar devices. The three systems of feeding the seed from the box to the tubes were what they had been ever since the machine was invented, namely, a grooved cylinder in the turnip drill, the brush or pinion, and the cup feed. Combined manure and seed drills were made by most of the firms in the business.

Harvesting Machines

The reaping machine may justly be said to have been introduced in the year of the Great Exhibition, 1851. The American machines made respectively by McCormick and Hussey were shown there, and they were by far the most practical. The idea was not, of course, new. From the late eighteenth century many people had tried to design a satisfactory reaping machine, but without complete success. Of these, that made by Patrick Bell embodied some of the modern principles. It had many vicissitudes, but survived from 1828 in practical, though limited, use until the exhibition. The cutters were on the scissors pattern; they were triangular in shape, point foremost. Each triangular plate, or finger as it is now called, was screwed in its place on a horizontal bar. The upper bar was given a reciprocating motion by gearing from the travelling wheels and the lower bar was fixed so that cutting was caused by the closure of the upper cutters in a scissors clipping manner. The grain was held or brought to the cutter by sails very similar to those on a modern machine. The cut corn was not tied—the knotter was not invented until much later—but fell upon a moving canvas that laid it aside in a swath. Most of these details were included in the machines that aroused so much interest in 1851. They were speedily shown at many other agricultural shows, demonstrated here and there, widely discussed and frequently improved in detail by English makers during the next decade.

A hay mower had been designed early in the nineteenth century, but it was not until the reaping machine had been accepted that it came into general use. Haymaking, after the grass had been cut, was a lengthy and tedious operation in the old days. It had to be cocked for safety overnight, spread again and windrowed by hand. A hay rake for horse traction was designed by Robert Salmon, of Woburn, in the second decade of last century. It was an axle on a pair of wheels, the axle shaft carried two smaller wheels, the rims of which were joined at regular intervals by horizontal bars, making a hollow cylinder. These horizontal bars carried iron teeth, pointing outwards, about 6in long. This arrangement revolved as the machine was drawn along; the series of forks scattered the hay in all directions, and over the driver and horse as well, if care was not taken to drive to leeward. A crank enabled the raking cylinder to be lifted out of work for travelling. Improvements in this machine were made by Wedlake, of Hornchurch, in the 1840s. Progress was rapid in this decade, and many firms took up the manufacture of haymaking machines. There were no less than thirteen competitors at the Royal Agricultural Society's trial in 1857.

A hay rake for laying the hay in windrows was adapted from the beam stubble rake, a simple bar riding on two wheels carrying a single row of teeth. When a lever was added for throwing the rake in and out of work this implement had attained its modern form. Another thing that had long been on the market was a hay sweep very like those used with a tractor to-day, but drawn by a pair of horses, one harnessed in front of either corner of the implement. It is not now possible to estimate how many farmers used these things in the 1850s, but those who did so must have saved a good deal of labour and have secured their hay crop with less anxiety than those who continued to do the work by the old manual methods.

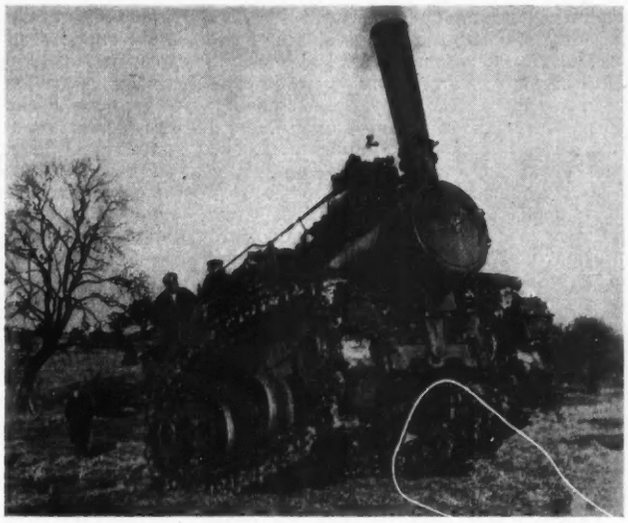
Conclusion

The engineers had already put many useful machines at the farmer's disposal a hundred years ago. Perhaps the two most important were the threshing machine and the seed drill. No less important was the seed dressing and winnowing machine. All these were in production, and the farmer who wanted one could easily buy it. Besides these there were many designs of factory-made ploughs and cultivators. The reaping and mowing machine had been in existence for some decades, but could hardly be said to be practical politics, nor was it in production. Haymaking machines were available in several different designs, rakes and sweeps had been produced, but it is doubtful whether many farmers used them. There was a wide range of barn machinery.

All these things were horse drawn, but steam power was on its way. Certainly, a century ago, the engineer and the farmer had begun to join forces to ease the burden of farm work. The reports of the Royal Show of 1857 (at Salisbury) emphasise this. The cultivation of the land by steam power was then occupying so much attention, it was stated, that "almost every day brings something new into notice." But next to steam culture and cartage, it was claimed, reaping and mowing machines were engaging the special attention of the agriculturist. A contemporary account of the 1857 Show commented that the cutting down of harvest fields by machinery was annually becoming a work of greater importance, and consequently, on the one side, engaged a large share of patronage on the part of farmers, and, on the other, was giving rise to "no small amount of keen competition among the manufacturers of machinery of this kind." The principal prize offered that year by the Royal Agricultural Society was one of £500 for a "steam cultivator," and one record of the trials says that "Mr. Burrell's engine, fitted with Boydell's wheels, ascended a steep hill on entering the field with great ease, dragging after it a large water tank and all the ploughs and tackle required." Moreover, in the showyard at Salisbury that year there were "some thirty steam-engines, driving combined threshing-machines, barnworks, mills and chaff-cutters." Much had already been done, but even those bright spirits could hardly have foreseen what would be achieved in the following century.

Centenaries of Engineering Firms

A leading article on page 971 of this issue refers to the centenary of the Science Museum at South Kensington, which was celebrated last Monday. This year, also, there are several engineering firms which reach their centenaries. In recent weeks we have received from three of them books which have been produced to place on record progress and development during their first century.



RUSTON AND HORNSBY, LTD.

TO commemorate the centenary of Ruston and Hornsby, Ltd., a volume entitled *One Hundred Years of Good Company* has been prepared by Bernard Newman. Like many books of its kind, it is something more than a bare record of an engineering company's growth ; it is a useful and interesting commentary on a century of industrial, social and economic progress.

The founder of the firm, Joseph Ruston, was born in Cambridgeshire ; he was educated in Sheffield, and remained there to become an apprentice in the cutlery industry. But at the age of twenty-two, Joseph Ruston was told—by a barber in Sheffield—about the millwright's business of Burton and Proctor, in Lincoln, which was for sale. That business had been established for about fifteen years, its premises being a shed on a small corner of what is now the Sheaf Iron Works, Lincoln. Burton and Proctor assembled, supplied and maintained portable steam engines, but they did not make all the essential parts ; their manufactures were limited to articles like ploughs and harrows. Joseph Ruston was impressed by the quality of the work turned out by Burton and Proctor. He saw the future of steam power for agriculture and he had inherited a modest sum of money from his father ! Ruston, for a start, went into partnership with Burton and Proctor ; thus there was established the engineering firm which is now celebrating its centenary. At the beginning, the firm's products consisted of simple steam engines, threshers, and smaller agricultural implements. It was not really many years, however, before the Ruston works were manufacturing road rollers and steam tractors, railway locomotives, stationary engines for a variety of uses, and pumps.

For several years, the firm specialised in agricultural machinery, though Joseph Ruston quickly demonstrated that he would supply power-driven machinery for all kinds of other purposes. The world was his field. Soon after Ruston joined the partnership in 1857, Burton retired, and seven years later, Proctor also retired. The firm continued, however, under the style of Ruston, Proctor and Co., Ltd. Among the outstanding achievements mentioned in the early chapters of the book is the development of the Ruston steam navvy. When, after some years of debate, the Manchester Ship Canal came to be started in November, 1887, Ruston received orders for seventy-one of these machines which were engaged on the work.

In recounting the history of Ruston's, however, the development of the Hornsby side of the present business is significant. The millwright's business, which subsequently became Ruston, Proctor and Co., Ltd., was started at Lincoln in the 1840s, and a few years earlier there had been established at Grantham " Richard Hornsby's Agricultural Machine Manufacturing and Iron and Brass Foundry." Again, the principal products were ploughs, seed drills and threshing machines driven either by animal or manual power. Richard Hornsby also manufactured some items of domestic equipment, including mangles and simple " washing machines." The Richard Hornsby, who started this business, was a farmer's son, and had served an apprenticeship as a wheelwright. For years, the two firms, the one at Lincoln and the other at Grantham, were carrying on similar kinds of business. The merger, resulting in the formation of Ruston and Hornsby, Ltd., did not take place until 1918.

The portion of the centenary book which deals with the production of the Hornsby-Akroyd oil engine is specially interesting. This engine, it is recalled, was first successfully manufactured in 1892 ; it was a horizontal hot-bulb engine of 11in bore and 15in stroke, producing 9½ b.h.p. at 200 r.p.m. The firm's subsequent work on oil engines has been, of course, varied and extensive ; it has included the introduction of vertical and cold-starting engines, and, in the 1920s, the adoption of the pressure-charged unit.

There are, however, other technical developments in which the Rustons or the Hornsbys were pioneers. One of them is the work on track vehicles which was carried out by Richard Hornsby's firm prior to the first world war. In 1908, the War Office offered a prize of £1000 for a " mechanical tractor which would run for forty miles without taking in additional supplies of fuel or water." A two-cylinder oil-engined tractor entered by Hornsby's won the competition. David Roberts, who had joined the firm in 1895, was managing director at the time of the competition. Prior to the competition he had been experimenting with a track fitted to a standard Rochet-Schneider automobile, and had demonstrated the equipment to a military audience at Aldershot. For a further demonstration, at a Royal review in 1908, another chain track " vehicle " was built ; in effect, it was a Hornsby 70 h.p. oil engine driving continuous tracks. Like many another technical achievement, however, the Hornsby chain track tractor had appeared too early to be a commercial success ! The American and Canadian patent rights were sold to the Holt Caterpillar Company of New York.

There was, nevertheless, one order which reached Lincoln in 1909 for a " caterpillar " ; the work on this particular machine proved to be specially significant a few years later in the production of tanks during the first world war. This order came from an engineer in the Yukon who was operating a coal mine more than 40 miles away from Dawson City. His problem was to get his coal to market ; there were no roads, the land was rough, and in winter the only method of communication was by sledge along the frozen Yukon River. Oil, this engineer said, was as precious as gold in the Yukon, but there was plenty of coal and water. His request was that Hornsby's should design a caterpillar tractor incorporating a steam engine instead of an internal combustion engine. By that time, however, the firm had discontinued the building of steam traction engines. The engine and boiler were therefore supplied by William Foster and Co., Ltd., and were mounted by Hornsby's on tracks. As the illustration at the head of this page shows, the traction engine mounted on caterpillar tracks presented an unusual appearance. It is said to have given satisfactory service in the Yukon, although there is no record as to the life of the boiler and firebox ! But there is a record of the vehicle's first experimental run. The machine weighed 40 tons, and various bridges in Grantham had to be strengthened to accommodate it. The driver got into some difficulty at the bottom of Spittlegate Hill, Grantham, the engine mounted the pavement and well nigh demolished the thick stone walls of a house. There were few further inquiries for this unique vehicle, yet the experience gained by its construction was undoubtedly useful to William Foster and Co., Ltd., who was called upon to make the initial experiments in building tanks during the first world war.

After the amalgamation in 1918, Ruston and Hornsby, Ltd., in common with the rest of the engineering industry, soon had to face the problems of peace. One project, in an endeavour to maintain employment, was motor car building. Cars of 16–20 h.p. and 20–25 h.p. were turned out, and there was no complaint about their quality and efficiency. The firm was not equipped, however, for the mass production methods of the automobile

industry, and car building ended in 1924; nevertheless, a Ruston car was still in service as a taxi in Melbourne in 1952! There is no need here to recount the firm's many developments in the succeeding years; they are all dealt with in the centenary book. Amongst the records of the work during the second world war, however, there is one that is specially interesting. It relates to the work done by Ruston-Bucyrus, Ltd., and Davey, Paxman and Co., Ltd. (a subsidiary of Ruston and Hornsby, Ltd.) in the production of "Nellie," the monster trench digging machine, which was described in THE ENGINEER of March 15, 1957.

No survey of a firm's progress over a century can be complete without many references to the people by whom the work has been done. Bernard Newman has written very ably about them; their contributions to the profession and business of engineering have been considerable. To-day, the firm, which started in such a small way a hundred years ago, employs over 9000 people in its works at Lincoln, Grantham and Colchester. An outstanding event in its centenary year is the opening of the research centre at Lincoln, as described in our issue of May 17.

HENRY SYKES, LTD.

Another centenarian is Henry Sykes, Ltd., a firm whose headquarters throughout have been in London. A brief account of its activities has been produced under the title *A Hundred Years of Energy and Enterprise*. The founder of the firm was Henry Sykes, who came to London, from Sheffield, when he was thirty-five, and set up a small engineering business in Upper Thames Street. Portable vertical steam engines, mortar mills, friction hoists and pumps were his principal products, and, in addition, Henry Sykes kept a stock of portable engines and boilers and hoisting tackle, which he let out on hire to builders and public works contractors. The firm continues to occupy premises in the neighbourhood in which it was started, and since 1930 has also had works at Charlton. Its centenary booklet shows that the present activities are in many respects the modern counterpart of those in which the founder was engaged. An interesting human touch about the booklet is that in a list of twenty-eight employees who have completed twenty-five years in the company's service, there are four who each have completed over fifty years, and five who have done over forty years.

ROUND OAK STEEL WORKS, LTD.

The third of the centenary volumes before us is *Steel at Brierley Hill*, which has been written by Collie Knox. It is an interesting story of Round Oak Steel Works, Ltd., which is now a member company of Tube Investments, Ltd. Originally, the Round Oak plant was the Earl of Dudley's Round Oak Iron Works. Though the Dudley family did not start the works until 1857, they were not really newcomers to the ironmaking industry. More than 200 years earlier, in Dud Dudley's days, they had gained a reputation as ironmasters.

The present works were founded by an Earl of Dudley, who already owned coal and ironstone mines, limestone quarries, sand pits and blast-furnaces. The works then had twenty-eight puddling furnaces, two hammers, two forge trains, and five rolling mills. It was twice as big as the average iron works of its day, covered fifteen acres and employed 600 men. The steel plant was started in 1890, but before it was completed financial difficulties had arisen and the owning company went into liquidation in 1894. But the steel plant, nevertheless, began operations as a department of the then Earl of Dudley's estates. A new company, entitled The Earl of Dudley's Round Oak Works, Ltd., was formed in 1897, and, although there was a recurrence of financial difficulties in the early 1920s, Round Oak continued virtually as the private property of the Earls of Dudley until 1951, when the steel industry was nationalised. With the denationalisation of the steel industry, Round Oak was acquired, in 1953, by Tube Investments, Ltd., by which time an extensive plant modernisation scheme was in hand. It included the building of a new melting shop.

As a supplement to the book, there is included a facsimile copy of "Rules made by or on behalf of The Right Honourable William Baron Ward, Proprietor of the Round Oak Ironworks, for the guidance of the several persons employed in or about the same." These rules, seventy-two of them in all, became effective on January 1, 1858, and the fines for a breach of any of them were clearly specified! Management undoubtedly managed, for Rule 71 reads: "All offences against these Rules will be enquired into and determined by the General Manager, whose decision shall be final and conclusive!"

Impact of Nuclear Energy on the Twentieth Century

By T. E. ALLIBONE, Ph.D., D.Sc., F.R.S.

At the Annual Convention of the Association of Mining Electrical and Mechanical Engineers, held last week in London, Dr. T. E. Allibone delivered the W. M. Thornton Lecture. We here reprint an abstract from that lecture. It refers to the possibility of generating power from the fusion of light elements and to the uses that can be made of radioactive isotopes.

WITHIN a few years of the discovery of the fission of uranium, scientists were beginning to think of deriving energy from the fusion of the light elements. One of the very first nuclear reactions studied in the early days of artificial disintegration was the bombardment of nuclei of heavy hydrogen, deuterium; it was observed that these nuclei fuse together and, in so doing, yielded very large amounts of energy because the compound nucleus is more stable than the nuclei from which it is formed. We know to-day that in the fusion of hydrogen nuclei to form helium there lies the possibility of releasing several times more energy than is released when the same weight of uranium undergoes fission. Unfortunately, all the particles taking part in this reaction are positively charged nuclei, and to force them close enough together for the short-range forces of fusion to hold them, they have to be endowed with very high velocities—that is, raised to high temperatures. In the stars, temperatures of many millions of degrees Centigrade are adequate to cause fusion to occur, and so is the temperture of an atomic bomb exploding inside a large mass of hydrogen. The exciting challenge is now held before the physicist of making a so-called controlled thermo-nuclear reaction operate, which will produce more power than is fed into the hydrogen to raise it to the requisite temperature.

At first sight you would imagine that no reaction involving a gas at a million degrees could operate in a vessel without instantly vaporising the walls of the vessel. This is not the case. Electrical discharges have been passed between metal electrodes in glass vessels and temperatures of a million degrees have been reached, because when a very large current is passed in a discharge tube the magnetic field carried by the current exerts a self-constricting force on the charged particles carrying the current, bunching them together on the axis of the tube well removed from the walls. Within the discharge column the pressure and temperature of the gas rises in a few millionths of a second and reactions involving the fusion of nuclei have already been reported, although these have not been regarded as true thermo-nuclear reactions, but have arisen from spurious effects. Attempts to achieve the true reactions are being made in several countries, for success will be one of the great prizes of the nuclear age. There will be three distinct stages in the later development as with fission: the discovery of those scientific conditions in which the reaction occurs; the development of a reactor which produces a net gain in power, and finally, the production of a prototype reactor. It is idle to guess when these stages will be reached. Only when the first is reached will it be possible to assess the magnitude of the second task, but when that is achieved the world will be assured of power for ever, since the deuterium content of the oceans is enough to supply our energy for millions of years. It is my opinion that these three stages will be reached within this century, possibly within ten years, and this is the reason for including this statement within my review.

One very attractive feature of the fusion reaction is that it is not necessarily accompanied by the radiation problem presented by tons of fission products, nor does it present an explosion hazard. Moreover, there is a possibility of generating electricity directly from the fusion reaction by linking the magnetic fields associated with the gas discharge with conductors around the containing vessel. In this way we might eliminate the thermodynamic steam cycle which has come to be associated with power generation, and if that occurs there will be a technical revolution as great as that which accompanied the discovery of the steam engine. But these things are for a future lecturer to describe to you. To-day, the problems are a little too distant for adequate assessment.

I have spoken mainly of the impact of nuclear engineering as providing a source of power of adequate magnitude for all our needs for the later decades of this century and for all time thereafter. There are other products of nuclear science which are also likely to influence our lives in this century. The fission products, the atoms into which the uranium atom disintegrates at the moment of fission, are intensely radioactive and within the next decades there will accumulate hundreds of tons of these active elements for which we can see little use at present. One or two of them, like caesium, are the most abundant and have very long periods of disintegration (caesium has a "half-life" of thirty-two years) so that the amounts will go on accumulating, far more rapidly than they will decay.

Gamma rays are absorbed in varying degrees by all substances, giving up a fraction of their energy to each molecule through which they pass, and thus they can cause molecular changes of various kinds. Relatively small intensities of radiation are lethal to human beings, but foodstuffs, such as meat and milk, are not noticeably affected by a radiation treatment a hundred times in intensity. At this level of intensity many radiation-sensitive bacteria are killed, and herein lies the possibility of the very large-scale use of radiant energy from the fission products. Unfortunately, a dose to kill all bacteria encountered in foods also produces undesirable changes in taste, odour and appearance, especially of meats and milk. Although considerable progress has been made in recent years in the study of these side-effects, they have

not yet been eliminated, and it is not possible to say yet whether they ever will be. If they were, then the wholesale irradiation of many foods might become practicable; whether economic it is far too early to say, since alternative ways of effecting improvements in food preservation might have been developed in parallel. What has been established thus far is that a radiation dose inadequate to spoil these foods in the slightest has extended the time that they may be kept wholesale at normal refrigeration temperatures.

A far smaller dose than this has been found to kill the life cells in potatoes and onions without causing any other damage to the nutritive value of these vegetables. Crops treated with gamma radiation show no softening or sprouting after eighteen months at ordinary storage temperatures; but again, the future potential treatment of them with radiation is a matter of economics, since chemical inhibitors may achieve the same result. Heat-sensitive anti-biotics which cannot be sterilised by the usual high temperature steam processes can be sterilised satisfactorily by gamma rays, and it has been suggested, and put to the test, that many pharmaceutical products and hospital equipment might be better sterilised with radiant energy than with steam. The whole subject, however, is in its infancy. Scientists will be faced with the huge amounts of radiant energy which will be the by-products of nuclear power. The fission products will, doubtless, have to be concentrated to ease the problem of storage and, frankly, we cannot see to-day how all this radiant energy can be used. The United States Army Quartermaster Corps is sufficiently concerned with the preservation of food, however, that it has ordered an experimental nuclear reactor of unspecified power for the sole purpose of studying the use of massive doses of gamma radiation in food preservation.

Radiation has been applied to inorganic molecules with some notable successes in recent years. The most commonly recognised achievement is the cross-linking of polyethylene brought about by radiation absorption in the polythene molecules. The aggregate is thus changed from being a mass of long-chain molecules held together only by weak surface forces into a solid in which the molecules are held together by primary atomic bonds, so strengthening the substance and raising its melting point to an amount depending on the number of cross-linkages thus formed. Many other radiation-induced molecular changes have been studied leading to structures either not capable of being produced so far by other known means, or produced only under special conditions of high pressure and with the use of catalysts. A considerable amount of research is being carried out to explore the great potentialities of this new tool for molecular synthesis. I must emphasise that these developments in chemical engineering are of very recent date and it is quite likely that chemists, having found new molecular structures produced by gamma irradiation, may be able to form those same structures by the more orthodox methods of chemistry, such as by using high pressures, high temperatures, and new catalysts; or electrical engineers may provide tools easier to manipulate than fission product sources to achieve the same irradiation processes. I can only sketch the possibilities of gamma ray chemical engineering and leave to the future the unfolding of industrial practice.

It is possibly in the realm of food and agriculture that large sources of radiation will have their greatest unchallenged effect for many decades to come. Radiation may be used to induce inheritable changes in germ plasm, and if these changes result in the growing of crop varieties resistant to pests and diseases the ultimate result might be far cheaper to attain than in the use of chemicals, fungicides, insecticides and weed killers. The new tool enables the plant breeder to induce changes far more rapidly than can be achieved by hybridisation and, although many new varieties will be discarded as exhibiting no improvement on the mother strain, some have already shown marked advantages. Already some plants have been produced which give higher yields; some mature earlier and can therefore be grown in colder climates, some withstand rough weather to a better degree because the stem is stronger, some are better suited to mechanical harvesting. Some trees and plants have a higher growth rate or are more resistant to diseases, viruses and fungi. The vast potentialities of this alteration to our main sources of food have hardly been touched. Enough has been achieved in a very few years to encourage an optimism that our world food resources may now keep up with the rapid growth of the world's population.

I have no time to do justice to the indirect consequences of nuclear energy to practically all our experimental sciences. Every year the Atomic Energy Commission, the Atomic Energy Authority, and similar bodies in other countries, supply many thousands of samples, large and small, of tracer elements which have been made radioactive by placing non-radioactive forms of these elements into nuclear reactors, there to be bombarded for varying lengths of time by neutrons. These tracer elements can be used, as their names imply, to trace the location of elements as they partake in chemical or physical reactions, and in countless researches they are leading us to more exact knowledge. This is particularly true in the life sciences where processes are generally so complex as to be difficult to follow by former methods, and the achievements so far are already remarkable. Tracers are helping to solve many problems connected with the application of fertilisers to soils and plants to ensure that the maximum yield is obtained and the soil improved by introducing deficient elements. Basic science, such as the elucidation of the mechanism of photosynthesis (the process by which green plants use the sun's energy to build up the complex molecules essential to life), is being followed by tracer elements and in later years may well lead to the discovery of alternate ways of converting this energy into chemical compounds. Tracers are making big contributions to animal husbandry, leading to a better understanding of the value of foodstuffs, the balancing of diets, and the supplying of essential elements, in various periods of the life of animals.

Medical science is so extremely complex that tracer elements are playing a dominant role in countless biological researches. The advantage of being able to measure gamma rays at a distance is invaluable in that it enables processes within a living animal to be followed after it has ingested a tracer element, without the animal having to be slaughtered. Isotopes have revealed, however, how much more complex biological processes are than had been expected. "A most complex state of affairs has been uncovered and for every problem which has been definitely settled, probably several new ones have come to light."* The fact that tracers have shown up these great complexities in such a short time, however, leads one to hope that with the passage of some years advances in the medical field will be revolutionary. In the Soviet Union the curative application of isotopes to malignant and benign tumours is regarded as important.

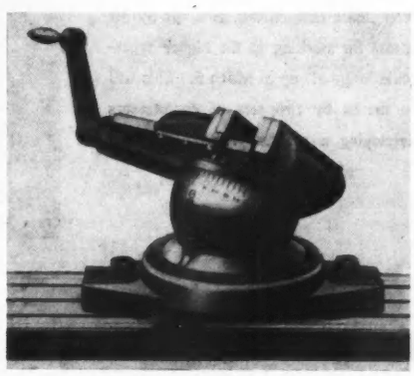
You are probably familiar with a variety of industrial applications of tracer elements. Some of them of importance to mining are the tracing of underground watercourses; to study the behaviour of water injected into wells to force up the oil; to test underground pipe systems for leakage; to assess the efficiency of filters in absorbing airborne dust; to map out the distribution of noxious effluence from chimney stacks; and to study the efficiency of coke production from oils. Applications of these kinds will continue for all time, but the great advances will be in the better understanding of fundamental processes, such as the kinetics of reactions, the diffusion and flow of elements in gaseous liquids and solid phases, leading to improvements in the refining of metals, and the interaction at surfaces leading to a better understanding of the processes of wear and catalysis.

This review is but a brief statement of the possibilities which have arisen out of the fundamental science of the first half of the century. Only the main lines of advance are discernible. What is most impressive is the way nuclear science appears to be able to make great contributions to all the other sciences, the life sciences and the exact sciences, and, above all, to offer a complete solution to the energy requirements of the world for ever.

* McFarlane, A. S., Vol. 10, *Geneva Conference*, 1955(United Nations, New York, 1956).

Universal Swivel Vice or Table

An equipment of Swiss manufacture which can be arranged as a universal swivelling vice, as shown in the accompanying illustration, or converted to a tilting work-table by replacement of the vice with a table, is now being marketed in this country by Trend Industrial Equipment, Ltd., 5, The Ridgeway, Stanmore, Middlesex. These equipments are available in two sizes—one with a vice having 3½in wide jaws opening to 3½in, and the larger with 5in wide jaws opening to 5½in. The vices are interchangeable with round or rectangular tee-slotted work-tables. The tables available for the small model are 6in



Universal equipment fitted with a vice. The vice can be replaced by a table

by 8in and 8in diameter, and those for the large model 12in by 8in and 11in in diameter.

The vices or tables are bolted to the spherical heads of universal bases, on which they can be swivelled through a full circle or tilted up to 45 deg. A spring-loaded dowel in the front of the base locates the vice or table at 15 deg. intervals. A lever projecting from the base locks the head in both the swivelling and the tilting motions against further movement after setting. Registers are fitted into both the vices or tables and the swivelling heads provide positive location when changing from one fitting to another.

Anti-Bridging Device for Storage Hoppers

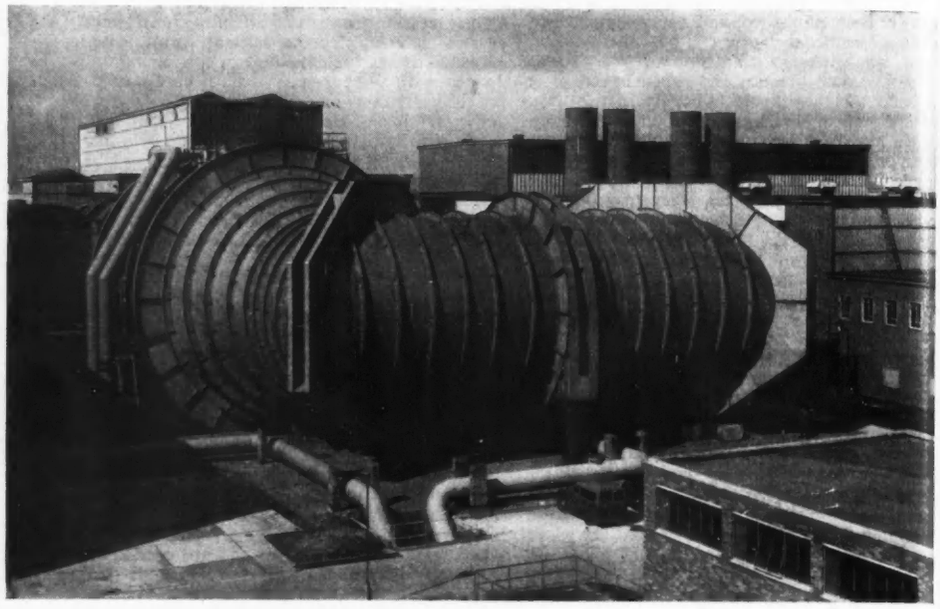
An American device which has been developed to prevent the bridging of bulk materials in storage hoppers has been introduced to this country by the Paterson Hughes Engineering Company, Ltd., Bedford House, Bedford Street, London, W.C.2. This device, known as the "Pneubin" pulsating panel, imparts pulsations on materials resting on the sides of a hopper to displace them and ensure a free flow.

It comprises a steel panel, the front of which is covered by a sheet of neoprene which extends to the back face, where it is firmly stuck. By alternately admitting and exhausting compressed air between the face of the steel panel and its covering, the neoprene is inflated and deflated to impart the pulsating effect. These pneumatic pulsating panels are made in a range of sizes from 4in by 12in to 24in by 72in.

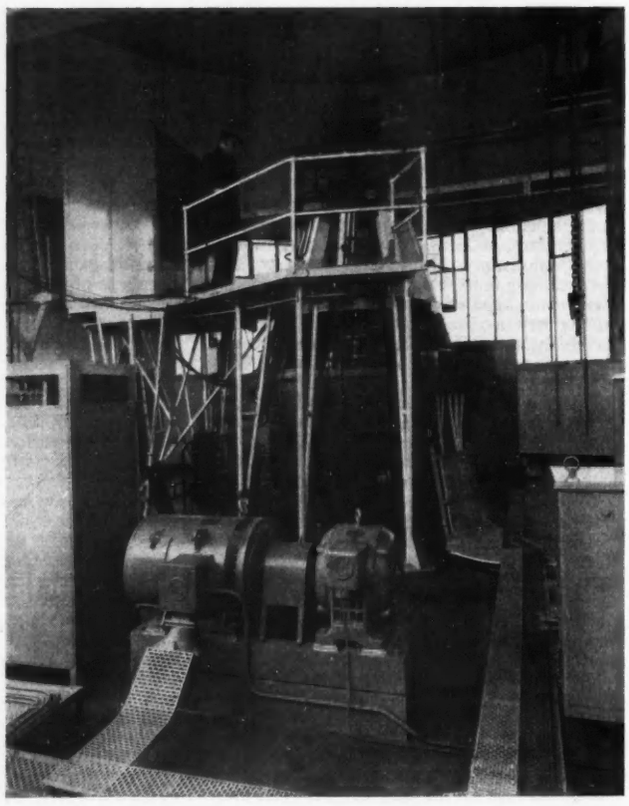
The steel panels are fastened by studs to the side of a hopper with the neoprene facing directly in contact with the material. Air inlet couplings incorporated in the steel panels are connected to a compressed air supply through controllers. These controllers can be set to give a pulsation frequency and amplitude in accordance with the nature of the material in the hopper. Three sizes of controllers are made to suit the sizes and number of panels used in an installation. The largest controller made enables a series of panels to be operated in unison or in series.

Wind Tunnels

The official opening of the Royal Aircraft Establishment, Bedford, took place yesterday. The establishment includes an airfield with a maximum runway length of 3500 yards at Thurleigh and a number of wind tunnels at Twinwood; some account of the latter was given in our issues of February 18 and 25, 1955. Now under construction is a 4ft by 3ft tunnel for working in the higher supersonic range of up to Mach 5. This will be driven by two sets of compressors developing a pressure ratio of 17 and absorbing 88,000 h.p.



The two upper illustrations show the 8ft by 8ft tunnel, designed to attain Mach 2·8 with 80,000 installed h.p. The heat equivalent to this power is removed from the working medium by a cooler situated at the largest section, 47ft in diameter, immediately upstream of the contraction leading to the nozzle. The water flow required is 5½ cusecs, and the pipes leading it to and from the fan-aspirated cooling towers can be seen. A severe requirement is uniformity of temperature and velocity downstream of the cooler, and no fewer than 58,000 1½in tubes, 16ft 6in long, are employed in it. The throughput of the cooler at peak tunnel density is 1200 lb of air per second, cooled from 160 deg. Cent. to 50 deg. Cent. The pressures in the tunnel range up to 46 lb gauge, and the energy storage is 1¾ million ft tons; the foundations of the cooler alone include 5000 tons of reinforced concrete. The highest pressure tests, to 60 lb gauge, were carried out with the tunnel filled with water, and the weight of the structure in this condition became the design case for the tunnel supports, one of which, giving vertical and axial constraint, is illustrated; it is situated near the end of the return leg, opposite the cooler



The spinning tunnel has a diameter of 15ft and can work with pressures up to 45 lb gauge. A vertical velocity of 95 m.p.h. at atmospheric pressure can be sustained in the 30ft high working section by an eight-bladed variable-pitch fan. This is driven at a constant 500 r.p.m. by a 1500 h.p., 11kV motor, and the 18-ton weight of the rotating masses is carried on a double thrust race at the top of the motor, seen in the third picture. The fan thrust and the pitch change forces are added to the starting load, the spherical roller bearing having a maximum capacity of 25 tons. The rotor and the 18ft shaft leading to the fan are hollow to lead the pitch control mechanism to the Lockheed hydraulic cylinder above the motor. The tunnel is provided with a remotely controlled launching gear to commence the spin when the tunnel is pressurised. The tunnel can also be used for the determination of roll characteristics, the model being then driven by a variable-speed gear

LITERATURE

Book Reviews

The Railway Station : An Architectural History. By CARROLL L. V. MEEKS. The Architectural Press, 9-13 Queen Anne's Gate, London, S.W.1. Price 60s.

ENGLISHMEN who travel frequently on British Railways, and with thoughts, maybe, of Clapham Junction, Liverpool Street, Crewe, or Birmingham New Street, might well raise their eyebrows at the mere thought of anyone thinking of writing an architectural history of railway stations, and still more so when they read the publisher's "blurb" of this book : "This is a study of the architecture of the western world since the early nineteenth century as exemplified by a single building type—the passenger railway station." In some curiosity one turns, inevitably at first, to the illustrations, and it is then, on studying the magnificent collection of drawings, and reproductions from old prints and photographs that the reason for the author's unusual theme grows clearer. He has attempted to study railway stations from three main aspects : as pieces of architecture, an architecture turned to serve a purpose that was entirely new in the mid-nineteenth century ; as examples of engineering, in the construction of roofs of huge spans, and finally as works of art. There is however, no consideration of stations in respect to the running of trains.

The author ranges from the early English examples, such as the Euston of Philip Hardwicke, and what he terms the Trijunct Station at Derby, of which Francis Thompson was the architect, to some of the earliest American and Continental essays. It is revealing, too, to study from contemporary drawings and prints the original aspect of many of our larger and more familiar stations. There are views of London Bridge, Chester, and Newcastle Central, which to-day are only faintly reconcilable—not because the buildings themselves have changed, but because they are now so encompassed with lesser and meaner erections as to be seen only at close quarters. There is no chance now to see them in the broad prospect originally possible. One looks back with mixed feelings, to an age in which business clustered round the great railway stations and building went on uncontrolled by any Ministry of Town and Country Planning ; but nevertheless an age in which the railways earned dividends for their owners, instead of the deficits all too familiar in our own age of "planning" !

But it is all too evident from the illustrations in this fascinating book that in most countries, except that of their origin, railway stations were regarded as sufficiently important features in a community to be given the finest possible architectural treatment and spacious location. They were treated on equal footing with the centres of civic life and culture ; and the Union Station at Worcester, Massachusetts, the Grand Central Terminal in New York, and the Stazione Centrale of Milan can be selected as outstanding examples of truly beautiful and impressive railway stations. The book includes illustrations of many interesting forms of roof construction, including an early print of the original roof at Charing Cross, of which Sir John Hawkshaw was engineer. This roof, it will be recalled, achieved something of a notoriety, when due to a fatigue crack developing in a major member a large part of the entire roof collapsed, on December 5, 1905. Such a failure has, however, been quite exceptional—nay, one might venture to say unique ; and to-day the great roofs of the pioneer railway stations of this country stand as surely as ever they did. Their interest and longevity may eventually prove an embarrassment to their owners ; for some, like Brunel's famous design at Paddington have been scheduled as structures of historic interest and must be maintained in their present state in perpetuity!

Where an intense business community has grown up round a railway station the tracks are hemmed in by property of high value, and traffic on the line develops to the point of extreme congestion, railway administrations in many parts of the world have been faced with a problem of critical importance : shall the station be moved to a new site, where space for a good modern layout is available, or shall the old, outdated station be modernised as best it can be, and attention given to improved means of traffic regulation on the existing tracks. Mr. Meeks instances the cases of Cincinnati and Buffalo, where what he describes as "a heroic decision" was made to move the stations far out from the urban centres, in order to build "as ideal a station as could be conceived." At Cincinnati in particular, so far as station architecture was concerned, the result was superb ; but there was, both in the location of the station itself and in certain aspects of its interior arrangements, a good deal of what Louis Sullivan has called "a public-be-damned design" ! A teeming business community has little time to appreciate the architectural beauties of great railway stations. The Londoners in their tens of thousands who use Liverpool Street daily would unquestionably prefer it where it is, and as it is, rather than a monumental new edifice where there is ample space for an ideal layout somewhere, shall we say, in the Hackney Marshes !

Nevertheless Mr. Meeks has produced a book of great interest and beauty, containing a clever analysis and dissection of the problems of the station builder over more than a hundred years of railways, and much that will be controversial as long as passenger transport by rail exists.

Nomograms for the Analysis of Frames. By J. RYGOL. Concrete Publications, Ltd., 14, Dartmouth Street, London, S.W.1. Price 18s.

THIS book, comprising fifty-three pages and twenty-six nomograms contained in a pocket in the back cover, presents a method of investigating, by the use of nomograms, rectangular frames subjected to various systems of loading. Single-storey, one-bay frames only are treated, consisting of two columns connected at the top by a horizontal beam with the three variations of fixed or hinged bases and hinged tops. For each of these three cases the book deals with various standard concentrated, distributed and triangular loads and externally applied moments, the total effect of any combination of these loadings being obtained by superposition. For each condition of loading a complete set of formulæ for moments and reactions is given, based on coefficients (equal in number to the degree of indeterminacy) which are functions of the properties of the frame and the nature of the loading. The advantage claimed for the nomographical method is the facility of establishing the indeterminate-statical quantities which are determined by reading from the appropriate nomograms the value of the coefficients for substitution in the formulæ. Should the solution obtained from the frame dimensions and properties first assumed be unsatisfactory, another solution based on different premises can quickly be obtained. The book also deals with cases where lateral sway of the frame under unsymmetrical loading is prevented by a restraining reaction at top beam level, though such instances would appear to be of academic rather than of practical interest.

The method of using the nomograms is very clearly illustrated by the adequate number of worked examples contained in the text. The volume is well produced and will be of service to those who have the task of performing repetitive calculations relating to the somewhat limited types of frame here dealt with.

Landslides in Clays. By A. COLLIN. Translated by W. R. Schriever, with a Memoir on Collin by A. W. SKEMPTON. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 52s.

IN 1846, Alexandre Collin, an engineer of the Ponts et Chaussées, published a book dealing with slips in clay cuttings, embankments and earth dams. Some twenty slips were described, the characteristic curved slip surface observed and measured for the first time, and the first clear explanation of the causes of instability in clay slopes was put forward. In addition, Collin carried out the first tests to measure the shear strength of clay samples.

His work, therefore, clearly deserved to to become classic, and it was indeed highly regarded for its practical sense at the time. But the deeper implications of Collin's contributions were not appreciated ; it was, in fact, too early for the realisation that here were the foundations for a quantitative analysis of the stability of clay slopes. Thus it was not until comparatively recent times, when soil mechanics had become established, that the full value of Collin's remarkable study became clear.

The present publication gives a full translation of the 1846 book, and all the plates are reproduced. All who are interested in soil mechanics can be assured that they will find it fascinating reading and they will also find the "Memoir on Collin," contributed by Professor Skempton, to contain far more than the few biographical notes which its title might convey. It is in effect a survey of the problem of slope stability in clays, together with an assessment of the value of Collin's work from a present-day viewpoint.

The book owes its existence largely to the initiative and enthusiasm of Mr. Legget, Director of the Division of Building Research, National Research Council, Canada, and the translation by W. R. Schriever is excellent.

Books Received

Atomic Quest. By Arthur Holly Compton. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 30s.

Aircraft Hydraulics : Vol. II, Component Design. By H. G. Conway. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

An Introduction to Workshop Practice. Second edition. By P. E. Ellis. Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 7s. 6d.

The Hypercircle in Mathematical Physics. By J. L. Synge. Cambridge University Press, Bentley House, 200, Euston Road, London, N.W.1. Price 70s.

Newnes Slide Rule Manual. Sixth edition. By F. J. Camm. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 7s. 6d.

Metallurgical Topics

Powder Metallurgy and Nuclear Research To-day

By H. W. GREENWOOD*

In an account of the recent Royal visit to the Atomic Research Establishment at Harwell,[1] it was stated that powder metallurgical methods have proved to be extremely important in fabricating materials such as uranium and thorium or beryllium and zirconium, into forms which can withstand the intense radiation conditions inside nuclear reactors. Some account was also given of the plutonium laboratory in the radiochemical building at Harwell and of the studies of the chemistry and metallurgy of the unusual materials of atomic energy.

Plutonium and its compounds do not emit penetrating radiation, but they are highly toxic materials, and so all handling of them is carried out in sealed "glove boxes" in which every chemical or metallurgical operation can be carried out. It is expected that plutonium will be the fuel of the future reactor systems, hence the study of the detailed chemistry and metallurgy of plutonium, its compounds and alloys, will be enormously important technologically. Much work has already been carried out and reported upon in the "Reports on Progress in Nuclear Energy,"[2] covering fundamental considerations, production of uranium by reduction of oxide or by electrolysis, production of thorium metal, beryllium and zirconium, and uranium and uranium carbide cermets. All this and much more from one laboratory indicates the volume of work that has been already done and suggests the colossal amount of investigation that still remains to be accomplished. Very much of this new knowledge is available as a result of direct application of powder metallurgical methods. In fact, it is permissible to say that quite a large part of results available up to the present are the fruit of application of powder metallurgical methods which are alone capable of producing the desired data and materials by which the earlier results may be applied, controlled and understood.

So rapidly have various research stations sprung up here and there in the land that it is a little difficult to assess the tremendous volume of work already done, and vastly more difficult to appreciate the work that still awaits initiation, control and development.

Concurrently with the progress in nuclear research there must be an equally important demand for apparatus, plant, materials, as well as chemical reagents for use in laboratory and workshop. Consider, for a moment, the group of what, only lately, we called the rare elements. We know, and have known for a long time, that many of them were present in the earth's crust in quantities far greater than several of the metals known as common and commercially useful. It often occurs that they are troublesome to convert from mineral, as found in Nature, to metal in ingots. In many cases unwanted impurity occurs in them and in quite a number of cases their chemical and physical properties have to be very fully studied before a suitable and, above all, economically sound method of recovery and purification can be made available. In the course of all this work we have learned much of the remarkable effects that could be the result of very minute quantities of specific impurities. The chemist, the metallurgist and the physicist have all benefited from the accession of new knowledge that recent activities in these fields has placed at our disposal and an increasing percentage of valuable results have come not fortuitously by empirical pot-mixing, but as a direct result of carefully planned experimentation carried out to practical ends.

Before the advent of the reactors, as we know them to-day, much work had been done in the field of electronics and many byways of research opened up which have richly justified the attention paid to them. A notable example has been the investigation of the field of semi-conductors and the new and special knowledge of progress during crystallisation. Much special investigation has added very notably to the surety with which further research can be planned and results obtained, clarifying available knowledge. A notable example is the application of methods of ion exchange to the separation of elements in complex or mixed minerals. Already there has accumulated[3] a most stimulating literature on the subject, a perusal of which indicates the very many directions in which ion exchange methods can be applied to numerous separations difficult to achieve by other methods. Very obviously the chemist and metallurgist of the future will be called upon to produce pure metals from raw materials containing a much lower quantity of valuable metal than is usually present in to-day's materials. True, modern methods of extracting, particularly the noble metals, can handle such small quantities successfully and in the future, as in the past, problems of this kind provide a challenge to the ability and technical knowledge of the technologist that he is rarely slow in tackling and meeting. A further sidelight on the nature and the intensity of modern research is thrown by the frequency with which the names of the rarer elements occur in technical literature to-day. Three names at once come to mind, which only a few years ago were hardly ever encountered, but which to-day seem to permeate technical books and papers. They are boron, lithium and thorium. Not only are names of elements such as these of common occurrence but the investigations into their behaviour either in reactors, or as additions to metals or alloys with a view to producing compounds having particular and desired properties, have provided or at least suggested new directions for investigations that have great promise. In fact, it would not be unduly exaggerating to claim that the last two or three years has witnessed progress of a volume and a value far transcending any previous period of like extent. In part this has come about through the expansion of carefully planned research and the increase in trained personnel that has become available to staff our chemical and metallurgical laboratories. Some of the results that have accrued to us have included a careful review of analytical methods, particularly of the so-called rare metals, and added to these have also come investigations of the metallurgical properties of alloys. A further useful result of recent work has been the making commercially available metals such as lithium, thorium, &c., at prices that are reasonably within the purchasing limits of the average laboratory.

For all, or almost all, metallurgical investigations powder metallurgy offers a means of covering a wide area in which the action and the effects of using a new or rare metal can be quickly and reasonably accurately determined. A notable result of comparatively recently published investigations is the demonstration of the potency of additions of quite small quantities of certain elements and the remarkable extension in physical properties which such additions can induce. In all cases where it is desirable to determine the physical properties of a metal or an alloy powder metallurgy offers a method that is easily controllable and which lends itself to a comparatively simple procedure and is also economical both in cost of material and in the manipulation of material during sintering or heat-treatment.

* Powder Metallurgy, Ltd., London.

REFERENCES

[1] *Nature*, March 23, 1957, pages 605, 607.

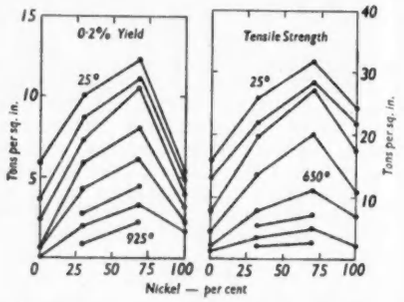
[2] "Progress in Nuclear Energy, Series V," *Metallurgy and Fuels*, Vol. 1 (1956).

[3] "Ion-Exchange Methods and Their Application to Metallurgical Problems," C. B. Amphlett, *Metallurgical Reviews*, 1956, Vol. 1, Part 4.

Tensile Properties of Copper-Nickel Alloys at High Temperatures

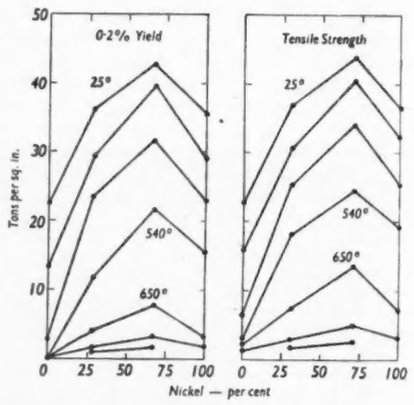
Short-time tensile tests at a rate of strain of 1 per cent per minute have been made at the U.S. Bureau of Standards* on copper, 70 : 30 copper-nickel, 70 : 30 nickel-copper and nickel at temperatures from 25 deg. to 925 deg. Cent. All the materials were of high purity.

As might be expected, the tensile properties were strongly dependent on the percentage of solute atoms in the component lattices, on the temperature of the test and on the amount of cold working that the materials had undergone. Figs. 1 to 3 are constructed from the numerical



Testing temperatures (in order of decreasing tensile strength) 25 deg., 150 deg., 370 deg., 540 deg., 650 deg., 730 deg., 815 deg., and 925 deg. Cent.

Fig. 1—Effect of nickel content and test temperature on the 0·2 per cent yield and tensile strength of initially annealed specimens



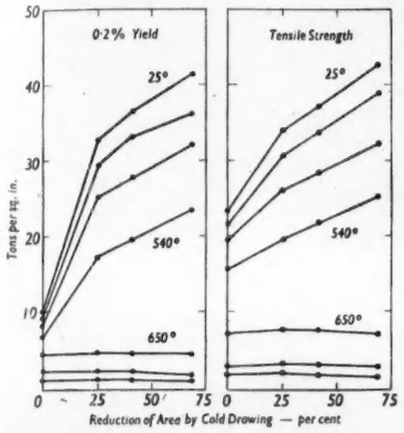
Testing temperatures (in order of decreasing tensile strength) 25 deg., 260 deg., 480 deg., 540 deg., 650 deg., 815 deg., and 925 deg. Cent.

Fig. 2—Effect of nickel content and test temperature on the 0·2 per cent yield and tensile strength of specimens of material initially cold drawn 40 per cent reduction of area

results and diagrams given in the paper. The compositions of the alloys are given in weight per cent, but on account of the similarity of atomic weight of copper and nickel they are not very different in atoms per cent of nickel, i.e. 31·6 and 71·6 atoms per cent respectively. The interatomic distances in the copper and nickel lattices are 2·55 and 2·49 A.u. (approx.), so the introduction of nickel into the copper lattice results in a contraction, and the introduction of copper into the nickel lattice in an expansion, of the lattice parameter. The increase in yield point and tensile strength for each 1 per cent of added nickel is greater in the range 0 to 30 per cent of nickel than in the range 30 to 70 per cent. Although the strengthening effect due to the solute atoms attained a maximum in the tempera-

* W. D. Jenkins, T. G. Digges and C. R. Johnson, *Journal of Research*, April, 1957, page 201.

ture range in which strain hardening occurred (150 deg. to 370 deg. Cent.) the effect was also evident at all the temperatures investigated. The 70 per cent nickel alloy is at each temperature appreciably stronger than the 30 per cent nickel alloy. This appears to be due to the greater intrinsic strength of the nickel lattice, since the relative increase in strength produced by about 30 per cent of copper in the nickel lattice is not as great as that produced by 30 per cent of nickel in the copper lattice. The increase in



Testing temperatures (in order of decreasing tensile strength) 25 deg., 150 deg., 370 deg., 480 deg., 650 deg., 815 deg., and 925 deg. Cent.

Fig. 3—Effect of cold drawing and test temperature on the 0·2 per cent yield and tensile strength of 30 Ni-70 Cu alloy

tensile strength produced by adding 30 per cent of nickel to copper was 73 per cent at 25 deg. Cent. and 187 per cent at 370 deg. Cent., whilst the corresponding figures for the addition of 30 per cent of copper to nickel were 31 and 65 per cent respectively.

The effect of cold drawing (with 0·2 per cent yield strength very near to the maximum load in the cold-drawn alloys) persisted up to about 500 deg. Cent., but was diminished with rise in temperature of testing, and finally was completely removed at temperatures above that of recrystallisation. The effect of the solute atoms on ductility varied appreciably with the temperature of test, the amount of cold drawing and the criterion by which ductility was measured (elongation, reduction of area or strain at maximum load). Increasing the grain size of the high-purity copper decreased its yield strength at temperatures below that of recrystallisation, and decreased its elongation and reduction of area at temperatures above that of recrystallisation. The effect of grain size in the other materials was not investigated.

Magnesium-Lithium Alloys

MAGNESIUM and lithium form two solid solutions, α with up to 5 per cent lithium, and β containing upwards of 10 per cent. The β solid solution (a body-centred cubic phase) and alloys containing a fair proportion of β were long ago shown to be very ductile.* The fact that age-hardening could be induced by the addition of a third metal suggested the possibility of obtaining a strong alloy lighter than magnesium, but unfortunately the hardness so produced is not permanent at room temperature, and the hardened alloys become soft on storage.

ALPHA-PHASE MAGNESIUM ALLOYS

A very full investigation, both experimental and theoretical, of the mechanical behaviour and associated structural changes of the α solid solution of lithium and other metals in magnesium has been carried out by F. E. Hauser, P. R. Landon and J. E. Dorn.† It may be recalled that magnesium has a hexagonal crystal structure and like other metals with this type of structure it is lacking in ductility and is brittle at low temperatures. The crystal structure of the α magnesium-rich, solid solutions is also hexagonal; but the solute metal produces changes in the lattice parameters and in the axial ratio c/a (a is the distance between an atom and any one of its six neighbours in the basal plane, and c the distance between parallel planes). The limited amount of deformation which occurs in magnesium before brittle fracture is due to the fact that slip is not completely confined to the basal plane, but occurs to some extent on prismatic planes. A reduction in the c/a ratio was thought likely to be effective in promoting more general prismatic slip which, coupled with basal slip, would furnish a greater number of independent slip mechanisms and might result in ductile behaviour over all ranges of temperature. Thus, one objective of the investigation concerned the possibility of introducing additional slip mechanisms by solid solution alloying.

Of the magnesium alloy α solid solutions tested at −195 deg. Cent., all except those with lithium fractured, after a few per cent strain, in an essentially brittle manner. In the 4·6 per cent lithium alloy, however, ductile fracture occurred after a minor amount of local necking at 17·3 tons per square inch and a strain of 12·2 per cent, or about four times that for pure magnesium.

The addition of lithium to magnesium decreases the c/a ratio. Other elements which decrease this ratio have such a limited solubility that only minor decreases can be effected by them. Consequently, lithium occupies a special position among the alloying elements for magnesium, because it alone appears to provide sufficient reduction in the c/a ratio to permit of extensive prismatic slip.

PROPERTIES OF THE MAGNESIUM-LITHIUM ALPHA-SOLID SOLUTION

As a result of extensive mechanical and metallographic tests on four magnesium-lithium alloys containing 0·76 to 4·6 per cent of lithium at temperatures from atmospheric down to 4 deg. abs., the authors of this paper concluded that solid solution additions of lithium increased the low-temperature ductility of magnesium, and that large amounts (e.g. 4·6 per cent) of lithium in magnesium solid solutions decreased the rate of strain-hardening in the alloy to such an extent that α-phase alloys of high lithium content have lower stress-strain curves than pure magnesium.

These magnesium-lithium alloys therefore appear to be an exception to the general rule that solid solutions are stronger than the pure parent metal. Whereas pure magnesium failed in a brittle manner between −195 deg. and +25 deg. Cent., with fracture strengths which were independent of temperature, the α-phase magnesium alloys of high lithium content failed in a ductile manner at all temperatures, exhibiting localised necking and a marked influence of temperature on the fracture strength. The increase in ductility and the decrease in rate of strain-hardening in the magnesium-lithium alloys seemed to be associated with the introduction of prismatic slip in addition to basal slip, and this in turn to the decrease in the c/a ratio of the hexagonal lattice resulting from the addition of lithium to magnesium.

Chemical Milling

A REVIEW by A. L. Forrester of chemical milling techniques used in aircraft production in the U.S.A. has recently been published,* and at about the same time a paper on "Acid Etch Milling," by T. M. Rohan,† described advances in chemical milling made at the North American Aviation's jet fighter plant, Columbus, Ohio. The method of milling by chemical means was first applied by them to aluminium components and for this purpose strong alkaline reagents were used. A new development was the use of hydrochloric acid as the deep-etching reagent. Acid baths are made by passing gaseous hydrochloric acid into the solution. This provides a means of maintaining the acid content of the bath at the desired concentration. The temperature, strength of acid and other factors are controlled to give a constant rate of etching of 0·001in per minute. Some cooling of the solution is required as all etching reactions are exothermic. Wetting agents and inhibitors are also added. Etch-milling of aluminium components may be carried out at room temperature or in some cases at 50 deg. Cent., with removal of metal at a maximum rate of 0·004in per minute. The great advantage of the process is that higher strength/weight ratios can be obtained by using heavier-gauge sheet and etching away areas of lowest stress. On a landing-gear door alone chemical milling reduces the weight by 11 lb without affecting structural strength.

The process is being extended to the etch-milling of more chemically resistant materials, such as high-strength alloy steels, stainless alloys, and even titanium. For titanium stronger acid must be used, but titanium sheet and some forgings have been successfully treated. Applications of chemical milling to titanium are also mentioned in Forrester's paper.

The main advantage of etch-milling is that, without endangering strength, it can remove excess metal from out-of-the-way spots where contour machining is difficult. Incidentally, it shows up inclusions and other surface faults which might not be observed in normal inspection. The cost of chemical milling varies with the complexity of the part and the depth of cut. In some cases etch-milling may be carried out at a quarter of the cost of the equivalent removal of metal by mechanical means. Because shapes almost impossible to machine can be etched, chemical milling is expected to become an important technique in extending the industrial uses of titanium.

Prot Fatigue Tests on High-Strength Steel

THE Prot method of fatigue testing is carried out under a progressively increasing load.* If the increase in stress per cycle is denoted by α, Prot showed that a linear relation should exist between the fracture stress S_r and $\sqrt{\alpha}$, viz., $S_r = S_0 + K\sqrt{\alpha}$, and that the fatigue limit S_0 could be obtained from a diagram of S_r against $\sqrt{\alpha}$ by extrapolation to $\alpha = 0$.

The value and limitations of the Prot method have been discussed in several papers since its introduction in 1948, and its validity in its application to heat-treated alloy steel of very high tensile strength (up to 175 tons per square inch) has been studied by P. W. Ramsey and D. P. Kedzie, who compared results with those obtained from Wöhler tests.† The material used was a nickel-chromium-molybdenum-vanadium steel, oil-quenched from 870 deg. Cent. and tempered at various temperatures, tempering being followed by water cooling. A useful increase in fatigue strength of carefully ground specimens was found up to about 150 tons per square inch tensile strength with an endurance ratio of about 0·40 to 0·42. With higher tensile strength the fatigue strength appeared to rise no further or even to fall slightly. Almost every fatigue failure began at a non-metallic inclusion, thus indicating the importance of cleanliness of microstructure in applications of high-strength steel subject to fatigue. There were some indications of a decrease in fatigue limit as the size of inclusions increased. The Prot method appeared to be a useful fatigue testing technique for this high-strength material and the results correlated well with those of the Wöhler method up to about 125 tons per square inch tensile strength. By means of the Prot method the fatigue limit could be determined with half the number of specimens and about a quarter of the test cycles required by the Wöhler method. It was concluded that the use of the Prot method for steels within the strength range indicated results in a worthwhile saving in specimens and test time without sacrifice of accuracy.

* W. Hume-Rothery, G. V. Raynor and E. Butchers, *Journal of the Institute of Metals*, 1945, Vol. 71, page 589.

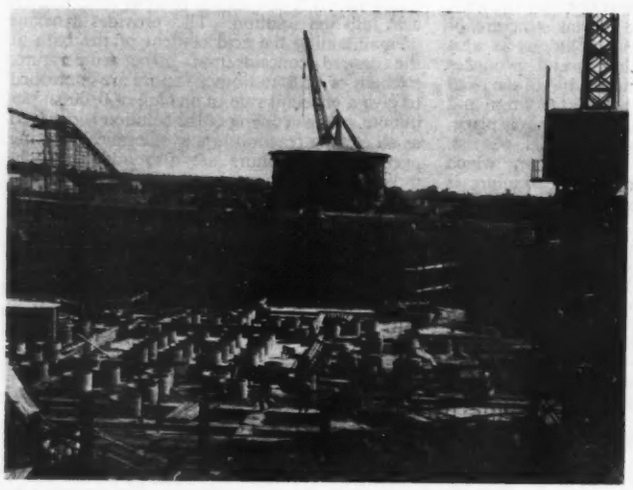
† *Trans. Am. Soc. for Metals*, 1957, Vol. 50, Preprint No. 5.

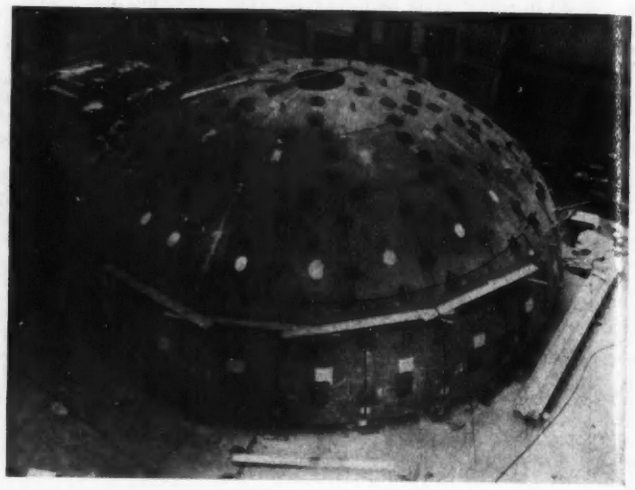
* *Sheet Metal Industries*, May, 1957, page 336.

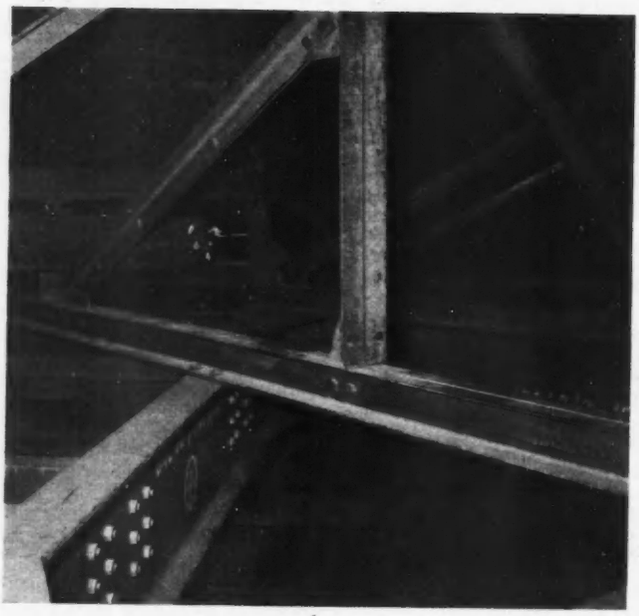
† *Iron Age*, May 16, 1957, page 114.

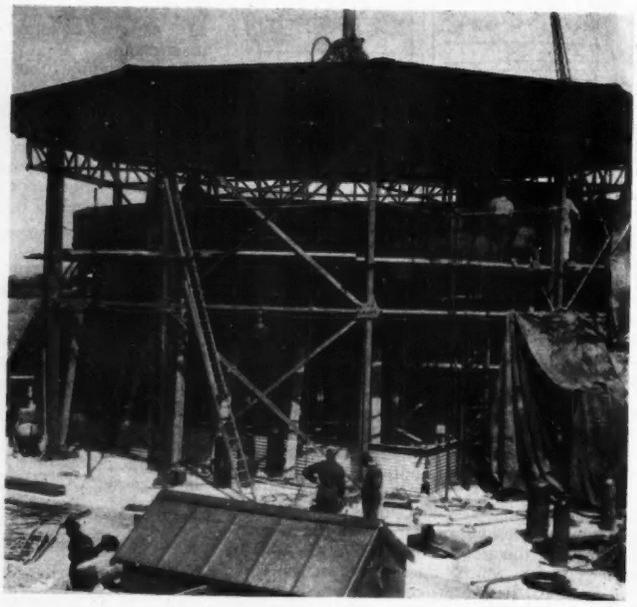
* *Revue de Métallurgie*, 1948, Vol. 45, page 481; 1951, Vol. 48 page 822.

† *Journal of Metals*, April, 1957, page 401.









Progress at Berkeley Nuclear Power Station

THE photographs reproduced on these pages illustrate progress in the construction of Berkeley nuclear power station, Gloucestershire. This station is being built for the Central Electricity Authority by the A.E.I.-John Thompson Nuclear Energy Company, Ltd. A brief description of the station as designed was published in our issue of January 25 last, page 143. Some of this information is repeated here to provide background information for the accompanying progress photographs.

The power station is being built on a 96-acre site on the Severn Estuary at Berkeley, Gloucestershire. A designed output of 275MW is to be obtained from an installation which will consist of two natural-uranium, CO_2-gas-cooled, graphite-moderated reactors, each supplying heat to eight steam generators grouped round it.

As can be seen from the accompanying view of a sectioned model, the core of each reactor is a vertical cylinder about 48ft in diameter by 30ft high, built up from machined graphite blocks and containing about 3000 vertical fuel channels. This core will be enclosed in a cylindrical steel pressure vessel, 3in thick and about 50ft in diameter and 80ft high. Protection from radiation will be provided by surrounding the pressure vessel with a thermal shield of 4in steel plate and a concrete biological shield about 8ft thick. Uranium rods just over 1in diameter sheathed in magnesium alloy cans will constitute the fuel elements.

Each boiler will be contained in a cylindrical steel pressure shell about 17½ft in diameter by 70ft high, and will raise steam at two pressures, 306 lb and 62 lb per square inch. The h.p. and l.p. steam will be superheated to 612 deg. Fah. and will drive four dual-pressure turbo-generators, each of about 80MW capacity.

Carbon dioxide gas at 125 lb per square inch will transfer the heat from each reactor, through 5ft diameter ducts, to the associated eight boilers. Eight variable-speed, axial-flow blowers, each driven by a 3000 h.p. induction motor through variable-speed hydraulic couplings, will be connected to the gas outlet of each boiler and will discharge the gas into the reactor vessel.

Steam from the boilers will be supplied at two pressures to 3000 r.p.m. close-coupled, tandem-compound, mixed-pressure, impulse turbines, which will be generally of conventional design, but will have triple exhausts designed for a back pressure of 0·43 lb per square inch. The generators will be hydrogen cooled and will operate at 11·8kV.

Circulating water will be taken from and returned to the River Severn providing a straight-through cooling water system with sufficient velocity in the intake tunnels and outfall culverts to inhibit silting. Cooling water for the reactor auxiliaries will be taken from a system connected in parallel with the turbine condensers.

The top left-hand illustration on the opposite page shows part of the excavation, 150ft wide by 30ft deep, for the No. 1 reactor house foundations. While construction of the foundations is progressing the bowl-shaped lower part of the reactor vessel is being fabricated in a temporary enclosure which can be seen in the background, beyond the excavation. To facilitate movement of the bowl into its final position it is being welded-up on a fabricated steel bogie, part of which, including one of the wheels, can be seen in the left-hand illustration (middle row). By the time the bowl has been fabricated its foundations should be ready, and then the bogie will be moved on rails to the required position. The bowl will then be jacked down about 6ft on to rocker supports, which allow for expansion of the pressure vessel during operation.

Before being transported to the Berkeley site the 3in thick plates that will form the lower bowl of the reactor vessel were fitted together in an inverted position on a large jig, to prove the accuracy of weld preparation and alignment. This operation, which was carried out at the Wolverhampton works of the manufacturer, John Thompson, Ltd., is illustrated in the top right-hand illustration on the opposite page. We learn that accuracy to within ¼in was achieved on the 50ft diameter of the bowl.

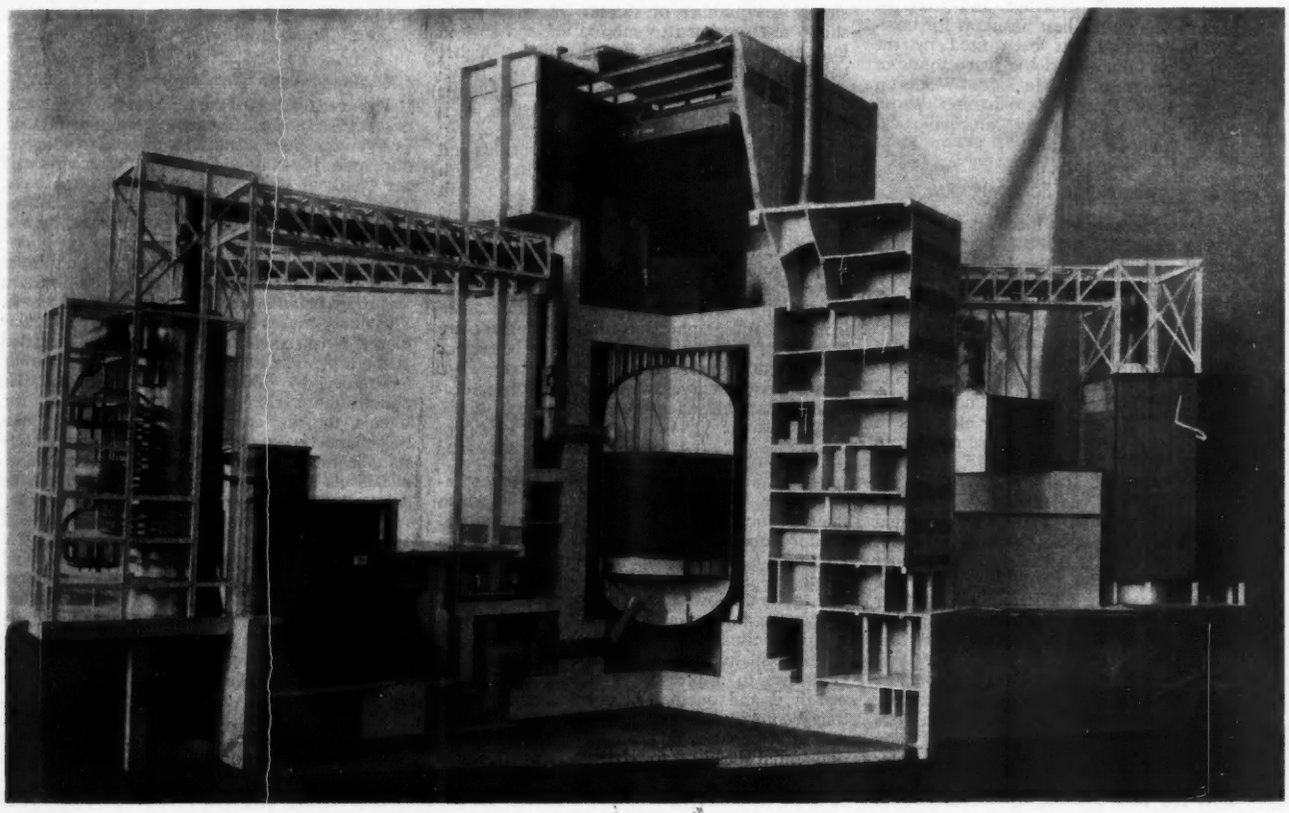
As can be seen from the illustration (right, centre) the bowl of the reactor vessel is being fabricated under a temporary cover, which can be raised as construction of the vessel proceeds. When the bowl is in its final position, the portable cover illustrated here will continue to be used while fabrication of the remainder of the pressure vessel and building of the reactor house walls proceed simultaneously.

The lower right-hand illustration shows the start of welding operations inside the bowl of the reactor vessel. Six teams of welders, working outwards from the centre weld the 3in plates, which have previously been assembled and held in position temporarily by clamps. Soon after the photograph had been taken other welding teams began work on the next ring of plates. An X-ray equipment ready for weld inspection can be seen in the background of this illustration.

The lower left-hand illustration shows work in progress on the foundations for two of the eight boiler towers associated with No. 1 reactor. The temporary shelter for welding the reactor vessel can be seen at the top right of the illustration.

A special organisation has been developed for site welding at Berkeley. Welders, previously trained or up-graded at the welding school at John Thompson's Wolverhampton works, completed their training and tests under site conditions at Berkeley by working on specimen pieces of 3in steel plate with various weld preparations. A special flame planing technique has been developed for the accurate edge preparation of the plates constituting the pressure vessel. The temperature of the weld area is maintained between welding runs with the help of flame torches. During the early stages of fabrication work studies were carried out to help the programme and to forestall delays.

The pressure vessel fabrication site is at present equipped with twelve 300A and twelve 600A individually controlled Lincoln d.c. welding sets for Class 1 welding. As site work progresses the number of welding sets will be increased to eighty.



Civil Engineering Models

The Institution of Civil Engineers held its annual conversazione on the evening of Wednesday, June 19, when members and their ladies were received by the president. The evening's traditional events included a display of engineering models in the library, some of which are described here.

RESEARCH and instrumentation in various subjects closely allied to the practical side of civil engineering were well to the fore in this year's exhibition of models at the Institution of Civil Engineers. Each year the models are lent for the occasion of the conversazione, by members who have been concerned with the work which the models represent. Thus, although the exhibition does not aim at any sort of comprehensive coverage, it does reflect new trends and developments, and the exhibits and models all have a special engineering interest of one kind or another.

Examples of measuring instruments of various kinds included a portable skid-resistance tester developed by the Road Research Laboratory to evaluate the coefficient of friction between a road surface (normally a wet surface) and a skidding tyre. Another class of measurement, which is valuable in recording offshore wave conditions, was exemplified by the National Institute of Oceanography's exhibit of a piezo-electric pressure recorder for the measurement of wave height. And in yet another field, an apparatus was shown by Professor J. W. H. King and Mr. R. M. Baker, which accelerates the curing of concrete so that seven-day and twenty-eight-day strengths can be predicted about twenty-four hours after casting the test cubes.

One method of measurement of recent origin has been applied to archaeological work. Members were able to see a demonstration (exhibited by Mr. C. L. Champion, of the Ministry of Works) of the use of soil resistivity measurements applied to the search for buried remains of ancient buildings. Subsoil investigation by boreholes, it was pointed out, always presents the risk that important underground features may be missed. The measurement of conductivity is a possible means for locating variations in hidden structure and may be valuable in selecting the best positions for boreholes. This method has been used by the engineering test branch and the inspectorate of ancient monuments of the Ministry of Works on possible sites of buried Roman and Saxon villages to determine where archaeological excavations would be profitable.

Instrumentation for Soil Mechanics

Two developments in soil mechanics measurements were of special interest. A gamma-ray probe used to determine the bulk density of material *in situ* was exhibited by Mr. H. Q. Golder (Soil Mechanics, Ltd.). It was developed in conjunction with the radio-isotopes division of the Atomic Energy Research Establishment to measure the *in situ* density of hydraulic fill at Palisadoes, Jamaica.

The principle behind the instrument is the "back scatter" of gamma-rays by electrons in the elements present in a soil. These rays, from a source of radioactive caesium 137, "bounce back" from the soil and are detected by a Geiger-Müller tube. The source and detector are housed in a stainless steel probe, separated by a lead screen so that only scattered and not direct radiation can be detected. The greater the bulk density of the ground, the fewer are the gamma-rays which reach the Geiger-Müller tube. Those that do reach the tube give rise to small electrical discharges across it, which are amplified as pulses and operate a counting unit called a "scaler." The count rate per minute can be calibrated against sands of different bulk density, and in the laboratory this has been done to within ±1 per cent. In practice a light alloy tube is driven into the ground, filled with water and the probe lowered down it. The effect of the light alloy has been allowed for in calibration. Details of the technique are soon to be published in a paper by Messrs. Bourne and Cameron.

The second of the soil mechanics measuring devices to which we referred was an automatic recorder for consolidation tests, due to Mr. M. G. R. Smith, chief civil engineer, British Railways (Western Region). In this test a sample of soil is subjected to a vertical load under which a variable rate of consolidation occurs. It is convenient to present the results of the test on a graph showing the decrease in thickness of the sample with respect to either the logarithm or the square root of time elapsed. The purpose of the machine is to produce this graph automatically. The co-ordinate of the graph representing decrease in thickness is produced by the rotation of a drum in the following manner. The movement sensing system consists of two contacts, one fixed to the beam of the consolidation unit and the other carried on a servo-motor-driven micrometer. The contacts control this servo-motor through a sensitive amplifier. The movement of the micrometer is transformed into the rotary motion of the drum by a synchronous motor and repeater. Variable amplification is achieved by a gear chain. The mechanism is sensitive to movements of 10 micro-inches and amplifies between 72 : 1 and 720 : 1. The time co-ordinate of the graph is produced by the movement of a pen across the drum at a velocity proportional to the square root or logarithm of time elapsed. The movement employs three inter-connected infinitely variable gear units.

The Vebe Test for Concrete

The Vebe test apparatus was developed in Sweden to assess the workability of concrete; it consists essentially of a slump cone mounted in a cylindrical container clamped to a vibrating table. The workability, in Vebe degrees, is simply the number of seconds required for a slump test specimen to subside under vibration into a compacted mass in the cylinder, higher values indicating lower workabilities. A transparent plate follows the surface of the concrete and the end point of the test is indicated when the whole of the underside of the plate is coated with mortar. The precise estimation of this end point was, however, found to be difficult with harsh mixes, and so an apparatus to permit autographic recording of the movement of the plate has been developed, and was exhibited by Dr. A. R. Collins, the technical director of the Cement and Concrete Association.

Apart from giving a more reproducible estimate of the Vebe degrees, the graphs obtained from the autographic recording equipment are proving of value in investigating the behaviour of different kinds of concrete under vibration. Characteristic curves were shown for under-sanded, normal and over-sanded mixes.

Studies in Hydraulics

The advantages of the Dall tube were demonstrated by Mr. D. H. Kent's exhibit, in which the Dall tube was compared with a conventional Venturi tube and a standard orifice plate. The Dall tube is a new differential-pressure producer which, it is considered, without site calibration, gives the lowest known percentage pressure loss at the differential heads required to operate any of the usual measuring units.

The Dall tube, in addition to being simpler, gives rise to a pressure loss varying between one-third and one-half that of a conventional long Venturi tube, depending on the throat ratio, and in some cases as low as 2½ per cent of the differential head; for large mains this can represent a very considerable saving in pumping or compressor costs, it is pointed out. At the same time, the Dall tube is between one-third and one-sixth of the length and weight of a conventional Venturi, and is easier to manufacture accurately.

Two factors explain the extremely low head loss. The first is that a "streamline curvature" head is added to the Bernoulli head, so that for a given differential head the throat can be larger than would be the case with a Venturi tube, thus reducing the head loss.

To achieve the required curvature at the throat, the angle between the upstream and downstream cones of the Dall tube is large, i.e. at least double that of the long Venturi. In spite of this, no breakaway occurs at the throat because of the annular gap (which has an action analogous to anti-stalling slots in aircraft wings), and the flow actually leaves the throat as a diverging jet. The second factor is that since this diverging jet follows the walls of the downstream cone, eddy losses are practically eliminated, while friction losses are small because of the short length of the cones.

A practical design problem in the tail-race of a hydro-electric power scheme where a large flood rise occurs, was demonstrated by Mr. H. D. Morgan's (Sir William Halcrow and Partners) model. The aim was to use stoplogs and not a sluice gate, which is more expensive, to close the outlet of a reaction turbine, into the tail-race.

In this particular case the flood rise downstream in the River Orinoco is 40ft. Should flood water enter the tail-race, its level may rise to as much as 50ft above the outlet. The size and weight of the stoplogs are so great that special methods are required to handle them, and the model showed one method which could be used. Three stoplogs were shown, each of which had a pair of lifting eyes just below the upper edge. These eyes registered with hooks hinged below their centres of gravity in a lifting beam working in the stoplog grooves.

To lower a stoplog, the lifting beam is directly carried from a winch above the top of the grooves. The swinging hooks are kept in engagement by the load hanging on them, but once the stoplog reaches the bottom of the groove, the hooks capsize to leave the lifting beam free to return to the surface. To extract a stoplog, the hooks are directly carried from the winch, the lifting beam then acting as a spacer. In this condition, the hooks hang in the same direction as when engaged with the lifting eyes of the stoplogs. The assembly is lowered down the grooves, the hooks are pushed to one side by the eyes until the points enter and the hooks are then engaged ready to lift the stoplogs.

Aerodynamic Stability of Structures

The investigation of the aerodynamic behaviour of a tall reinforced concrete chimney stack at Ferrybridge power station was briefly noted in our issue of May 31 last, on the occasion of the National Physical Laboratory's open days. This research was again demonstrated at the conversazione, with a model exhibited by the N.P.L.'s director, Dr. G. Sutherland.

The stack was set in oscillation by firing thrust units from the top, and the decay of the vibration was recorded in a mobile laboratory at the base. The vibration was measured in two perpendicular planes by piezo-electric accelerometers installed at the top. The outputs were fed to the mobile laboratory by 200-yard cables, where, after double integration and amplification of the signals, the displacements were recorded on a two-channel pen recorder. The equipment is suitable for measurements down to frequencies of 0·5 c/s and an amplitude of 0·001in can be detected.

This work is noteworthy for the high degree of accuracy achieved. Apparently the negative aerodynamic damping predicted, at certain wind speeds, from model tests is greater than that observed in the full-scale tests, but we understand that under certain conditions the stability of the stack is marginal. Fuller results would doubtless be of interest.

An investigation into the possibility of aerodynamic buffeting (see THE ENGINEER, May 13, 1955) of a proposed suspension bridge across the Tamar close to the Royal Albert bridge, was illustrated by sectional models from Messrs. Mott, Hay and Anderson.

Scale models of portions of the proposed road

bridge and the existing Royal Albert railway bridge were to be seen. They were constructed for wind tunnel tests to determine the aerodynamic stability of the proposed suspension bridge; furthermore, because of the proximity of the proposed bridge to the existing railway bridge (Royal Albert bridge) at Saltash, it was necessary to consider the possibility of oscillations, arising from buffeting as well as from aerodynamic instability, and to include tests to establish that the new bridge would have no buffeting effect on the existing bridge. The centre span proposed for the suspension bridge is 1100ft and the two side spans are each of 400ft. The bridge will provide a 33ft wide carriageway with two footpaths each 6ft wide.

Large Civil Engineering Schemes

Although we have tended to concentrate on research and measurement in those exhibits from the conversazione which we have selected for description here, it should not be overlooked that those large schemes of construction which are the central business of the civil engineer were well represented by models and dioramas. Some of these schemes will already be familiar to our readers, and so we mention here in the briefest manner, only one or two of them. However, this article concludes with some notes on two recent structures, models of which were to be seen at the Institution. Others included a model of Kariba dam, an explanation of a soil and land classification survey for the Shire Valley scheme, railway reconstruction at Barking, and the Berkeley nuclear power station in Gloucestershire.

Architectural elegance was noteworthy in the model of the new terminal buildings now under construction at Gatwick airport, shown by Messrs. Frederick S. Snow and Partners. The new layout is for a single runway and involves diversion of the London to Brighton road. Completion is scheduled for the spring of next year.

An interesting feature of the Mercer steam power station, now under construction in New Zealand, is that part of a hill was removed in order to accommodate it. The nature of the available ground would otherwise have necessitated the construction of an expensive buoyant foundation raft. It was found to be more economical to expose strata upon which simple block foundations would be satisfactory. The design of all buildings and plant makes allowance for seismic disturbance. The station will be of 180MW capacity, and a diorama illustrating it was shown by Messrs. Preece, Cardew and Rider.

Avon Dam

A diorama and coloured photograph of the Avon dam of the South Devon Water Board was exhibited by Mr. J. M. L. Bogle, of Messrs. Lemon and Blizard. The dam is a mass concrete gravity dam 870ft long, curved in plan to 1200ft radius, and 110ft in height at the centre. It will have a storage capacity of 305 m.g., giving a gross yield of 4·3 m.g.d. The granite aggregate is quarried and crushed on site. Gap-graded mixes have been designed and in the hearting concrete 4in maximum size of aggregate is used. The precast concrete blocks with which the dam is faced have the aggregate exposed on the downstream face and are laid in 4ft lifts before the hearting concrete is poured, thus eliminating the use of shuttering on the exposed faces.

As low heat cement is not manufactured in this country, a mixture of 30 per cent Portland cement and 70 per cent granulated blast-furnace slag ground wet by the Trief process has been used, to avoid the high rise in temperature in mass concrete made with ordinary Portland cement. This has been a great help in the construction of the dam, as it has enabled the period between pouring of adjacent monoliths to be reduced to eight days and the whole length to be brought up almost simultaneously.

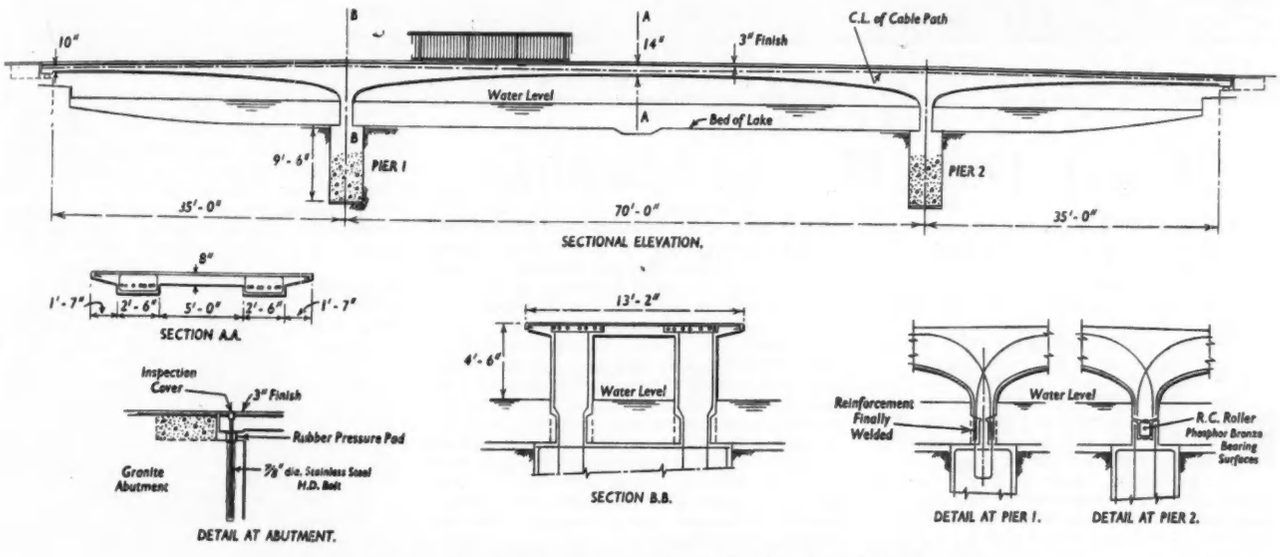
Provision has been made during the construction of the dam for its future raising by post-tensioned cables. By setting 21in diameter concrete tubes in the dam, vertical holes have been left in the correct positions to take the steel cables which will enable an additional 15ft to 20ft to be added to the height of the dam, thereby increasing its capacity by 50 per cent, and adding 1,000,000 gallons a day to the yield. Thus, several features of the construction of the Avon dam, as can be seen, are characteristic of recent trends in this class of work, and have been paralleled by dam construction in the Scottish Highlands.

St. James's Park Bridge

Remarkable grace and slenderness has been achieved in the form of several footbridges which have been built at various sites in the past few years in prestressed concrete. The most recent example of this class of structure is one which will be particularly in the public eye since it is being built across the ornamental lake in St. James's Park, where it will replace the well-known suspension bridge.

A model of the new bridge—the structural work for which is now at an advanced stage—was shown by Mr. G. C. Greetham, chief structural engineer of the Ministry of Works. The structural form of the bridge is shown in the accompanying drawing, from which it may be seen that that particular architectural elegance which is characteristic of well-conceived prestressed concrete design has been achieved. The main span is 70ft, and the depth at the centre of this span is only 14in, including 3in for the "finish" of the surface; a light handrail completes the elevation.

The path of the main cables is almost straight, dropping in the centre span to the lower part of section, as the illustration shows. It was found impossible to define a concordant path for the cables over four supports. So at the time the cables were stressed, the bridge was arranged to rest in a simply-supported condition on the two piers. Thus, as the cables were tensioned, the two side spans were free to lift slightly off the end supports, cantilevering from the central span. When the stressing operation was completed, rubber pressure pads were inserted under the end supports, and the ends of each cantilever were secured by holding-down bolts, as shown in the detail on the left of the illustration. Thus it will be seen that for the dead load the bridge behaves as a central span with two cantilevers, but for live load it behaves as a continuous beam over four supports. Note the concrete hinge shown in the detail at pier 1; this ensures simply-supported conditions for prestressing, but the reinforcement will later be welded across to make a rigid support; pier 2 will remain flexible, as shown. The Gifford/Udall cables give a total prestressing force of 700 tons. The concrete for the bridge was cast with white cement and Portland stone aggregate to give a decorative finish (the decorative "fascia" of the Clifton Bridge at Nottingham, described in this journal a few weeks ago, may be recalled). The aggregate is not the true Portland stone, but is cap stone which occurs above the stone used for masonry, and is itself too hard for masonry work. We are informed, however, that it is very suitable for concrete aggregate and strengths of 8000 lb per square inch at twenty-eight days have been obtained from the concrete, with a water/cement ratio of 0·47. The bridge has been designed by the engineering and architectural staff of the Ministry of Works, the main contractor being Higgs and Hill, Ltd. It is expected to be complete by September.



Details of the prestressed concrete footbridge now under construction in St. James's Park, London

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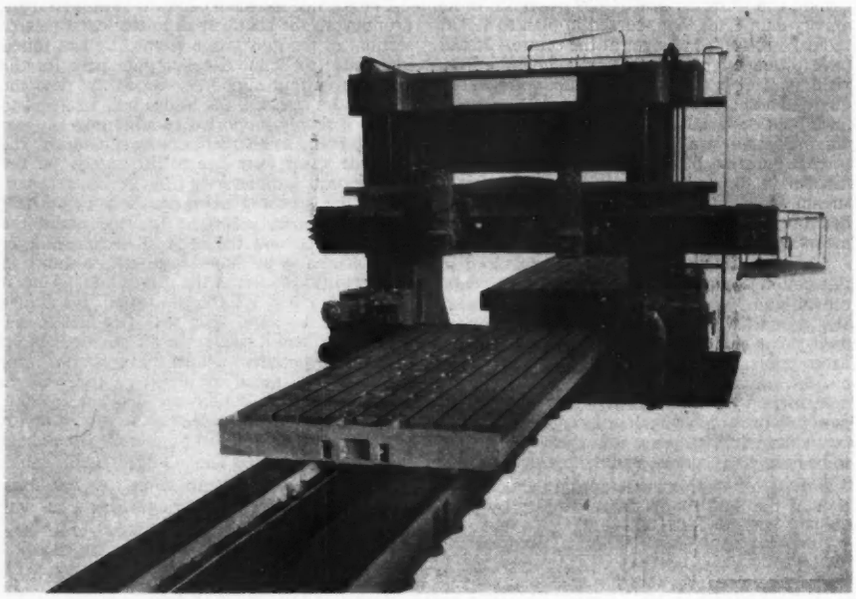
Steel Tubes and Bars.—A booklet recently published by the Talbot Steel Tube Company, Ltd., Green Lane, Walsall, contains the data most commonly required by engineers, designers and buyers, for steel tubes, bars, flanges, fittings and associated industrial products.

V-Belt Drives.—A maintenance manual, published by British Tyre and Rubber Company, Ltd., Herga House, Vincent Square, London, S.W.1, deals with the factors governing V-belt drive design and is intended to show how, by observing a few simple precautions, V-belt users can prolong the life and increase the efficiency both of the belts and the driving and driven machinery. It covers the installation and care of V-belts, their alignment, adjustment, tension, storage, fitting, cleaning and life-expectancy. The final part of the book describes "BTR" all-purpose V-belts designed to operate in hot, oily, corrosive or explosive atmospheres.



Heavy duty planing machine with two 25ft long work tables on a 110ft bed. Work up to 8ft high and 13ft 6in wide can be planed on this machine, which is fitted with two tool boxes on the cross slide and one on each side housing

Heavy Duty Planing Machine

ON large planing machines an appreciable amount of useful machining time can be lost in loading and unloading work on the table, particularly when large and heavy pieces of non-uniform shape have to be positioned, packed and clamped in position. A large capacity heavy duty planing machine with a very long bed and two work tables which has been designed and built by Noble and Lund, Ltd., Felling-on-Tyne, for Ruston-Bucyrus, Ltd., enables the time lost in this way to be reduced to a minimum. With this machine, which can be seen in the illustration above, one table can be engaged in the planing operation whilst the other can be positioned at the far end of the bed and loaded with the next part to be machined. Each table of the machine is 12ft wide by 25ft long, and when it is required to plane large work-pieces up to 53ft long, the two tables can be coupled together to form a single unit. The machine takes work up to 8ft high and 13ft 6in wide between the uprights.

The rigid cast iron bed of the machine has broad flat slideways, and its length of 110ft gives sufficient room for a table to be parked at either end for loading whilst the other table works over its full 25ft stroke. It is made in sections bolted and keyed together, and set-screw operated wedges for levelling are spaced along the base. The deep box-section tables also are made in sections bolted and keyed together, and they are fitted with adjustable slips for side guiding purposes. Each table has on its underside a machine-cut steel rack, to which the drive is taken from the main motor situated in the rear housing of the machine through spur reduction gearing and pedestal-mounted final drive gears in the well of the bed. The 100 h.p. d.c. main motor runs at 83/750 r.p.m., and through the reduction gearing gives an overall table speed range of 13·3ft to 120ft per minute. The bed slideways are lubricated by the maker's "Fluilink" equipment, the pump of which is driven by a motor interlocked with the main drive in such a way that the machine cannot be started until oil is being fed to the ways. In the event of the supply of lubricating oil stopping the main motor is automatically switched off.

The massive box-section side housings of the machine are bolted and keyed to the bed and rigidly supported at the top by a deep cross beam. Wide machined ways on the front of these housings carry the cross slide, which is made very deep with a large bow at the rear to prevent undue distortion under the heavy cuts of which the machine is capable. This slide can be locked in any required position on its ways and is raised and lowered by vertical screws. These screws are set well out from the faces of the housings to pass through nuts near the middle of the cross slide in order to avoid any tendency for the slide to heel over on its ways when it is unclamped for raising or lowering.

The two tool boxes of the cross slide are mounted on carriages with swivelling and vertical feed slides, and their front swivelling flapper boxes incorporate solenoid operated tool lifting gear which automatically comes into effect on return strokes of the table. A side tool box on each housing is balanced by weights which pass down inside the housing. These side tool boxes have graduated swivel slides with horizontal hand adjustment, and are also fitted with solenoid operated tool lifting gear.

A large gearbox on the top of one side housing contains the mechanisms for the feed and quick traverse motions, and individual clutches provided for each of the tool boxes enable their feeds to be started, stopped or reversed independently or collectively as required. The maker's "Fluifeed" hydraulic transmission system operates the feed motions at the end of the return stroke of the table of the machine, and through a hand wheel the feed rates can be steplessly varied from 0in to ¾in per stroke. A 20 h.p. electric motor mounted on top of the feed gearbox provides the drive for the quick power traverse motions of the tool boxes, and for raising and lowering the cross slide. This motor is push button controlled and the quick power traverse drive is transmitted through the same clutches as are used to engage the feeds in each direction of travel. The quick power traverse is designed to overrun the normal feed, so that it can be engaged as required to save machining time when planing parts with long spaces between faces.

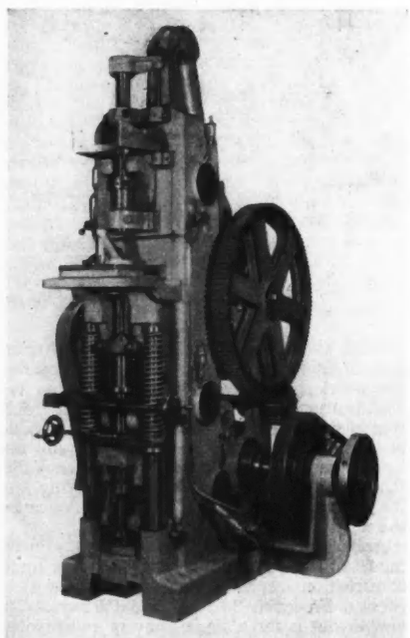
Directional control levers are provided in convenient positions for the tool boxes, and operators' platforms are arranged at each end of the cross slide. The control gear for the machine is in the front upright, and into its panels are fitted the controls for the cutting and return speeds of the table and the switches for the tool lifting solenoids. A reversing switch for the table is operated by tappets which are adjustable in a slot along the sides of the tables, and the cutting and return speeds of the tables are shown on a large dial at the control panel. A pendant control, with switches for starting and stopping the tables and the quick traverse motions, gives the operator the degree of mobility which is required when working on such a large capacity machine.

Tablet Press

THERE was recently demonstrated at the works of Apex Construction, Ltd., of 15, Soho Square, London, W.1, a prototype of the firm's "146/5" tablet machine which is expected to be particularly adaptable for powder metallurgy and other powder compression processes calling for very close control. The press is a cam-operated, double-acting machine, with an upper and a lower punch and a core rod. It can be arranged with a movable instead of a stationary core rod, or fitted with a secondary bottom punch instead of a core rod, or with a secondary bottom punch and a stationary core rod. The maximum pressure exerted is 40 tons and with its maximum depth of fill the press can produce pieces up to 3in diameter. The upper punch stroke is 5½in and the lower punch stroke from ⅛in to 2⅜in.

The punch motions of the press can be controlled independently of each other, so that pressure can be applied on the material in the die both from the top and bottom either simultaneously or non-simultaneously, or, if required, top pressure alone can be applied. There are one upper punch and two bottom telescoping punch mechanisms, each with independent movements. The inner bottom punch can be used as a stationary core rod, a movable core rod or a secondary lower punch. Thus pieces with flanges, concentric projections or holes, or holes only part way through can be produced. The auxiliary punch, being separately controlled by its cam, results in pieces of uniform density being produced—even when the part has different pressure levels required by its varying sectional thickness.

An excess pressure release and pressure equaliser available with the machine operates a hydraulic cylinder on the upper punch and compensates for any normal variations in the amount of powder fed into the die.



Cam-operated, double-acting 40-ton tablet press with stepless stroke adjustment of lower punch

The movements of the punches are varied by the introduction of inserts in the driving cams to alter their effective radii, but the prototype machine illustrated is fitted with a means of stepless stroke adjustment for the bottom punch. This mechanism eliminates changing inserts on the bottom punch cam to adjust for different sizes of tablets and materials. Through a mechanical linking system and two handwheel-operated setting nuts on the lower punch post adjustments for the compression, die filling and ejection levels of the bottom punch are interconnected.

Closed-Cycle Air Turbine for Naval Use

A Paper with the title "A Closed-Cycle Air Turbine for Naval Use" was presented by Dr.-Ing. W. Spillman before the International Congress on Combustion Engines, held recently in Zurich. An abstract is given here.

HIGH cruising economy is particularly desirable for marine gas turbines. The high part-load efficiency of a closed-cycle turbine allows this aim to be achieved without breaking the main power unit down into basic load and booster engines. It might be of interest that the said special performance characteristics are feasible with a simple type of plant without a complex cycle of any kind.

A design with such a performance was used for the first time on a 10,000 s.h.p. prototype marine plant. The plant is designed to burn diesel fuel and for use as a test bed for handling residual fuel. The design pressure ratio is 3·8 and a pressure of 17 ata (240 lb per square inch absolute) at compressor inlet has been chosen for full load. The air heater is of the multi-combustion chamber type with combustion air preheater. The power turbine has to drive a variable pitch and reversing propeller at 350 r.p.m.

Closed-cycle gas turbines can be controlled by varying the system pressure at constant temperature. With this control principle the cycle is operated at a constant ratio air mass flow/system pressure level. For given flow sections, therefore, the gas velocities at any place in the cycle are constant and the turbines are running at congruent velocity triangles. The internal blading efficiencies are therefore approximately constant for all loads.

The plant will run under any condition with constant cooling water flow. This leads to a smaller temperature difference between cooling water and cycle air at part load, resulting in a higher compressor pressure ratio. With tubes having extended surfaces on the gas side this influence is even more marked.

The turbine inlet temperature has not been kept constant, being 725 deg. Cent. (1340 deg. Fah.) in the cruising range and 670 deg. Cent. at higher loads. There are two reasons for this temperature shift. Foremost, the character of the efficiency curve showing high part load economy will be improved. On the other hand, it increases the difference between combustion chamber outlet temperature and cycle temperature. The high temperature drop gives a reduction of the size of the air heater and leads to an almost constant tube wall temperature.

Obviously there are no serious design difficulties for the air heater especially because the results of a large number of ordinary creep tests and the experience from 30,000 hr tests with tubes under pressure at 750 deg. Cent. were available.

Taking into account the shape of the temperature curve and combining all influences, including a compromise for the variable speed power turbine, the maximum efficiency occurs in the cruising range between 10 and 30 per cent of full power. For the 10,000 s.h.p. plant the expected thermal efficiency, including all mechanical losses as well as losses in the reduction gear and air heater, is 27 per cent for 10 per cent output (234 g/s.h.p.h ; 0·5 lb/s.h.p.h) and 19 per cent at full power (330 g/s.h.p.h ; 0·73 lb/s.h.p.h).

Special development work was needed for the air heater, which comprises eight identical elements, each with a combustion chamber and a primary and secondary convection section.

The air heater works under similar conditions to other heat transfer equipments. Tubes with small internal fins are used in this special type of combustion chamber and external fins are provided for the primary convection section. In spite of decreased heat transfer coefficient at low density the efficiency increases for part load due to the low combustion gas outlet temperature.

Tests showed that the tube wall temperatures can be kept within acceptable limits even for sections where extreme conditions are present.

In thirty test tube sections there was only one with a large variation of the local temperature; all the others showed temperature variations of less than plus or minus 10 per cent.

The complex measurements, carefully carried out on the test bed, showed that the design parameters originally chosen are feasible. The design of the air heater was made for a volume heat load of $1 \cdot 65 \times 10^6$ kcal/m³h (180,000 B.Th.U./cu.ft h) (combustion chamber only) and a tube surface heat load of $0 \cdot 2 \times 10^6$ kcal/m²h (22,000 B.Th.U./cu.ft h).

As a result of the approximately constant cycle temperatures, the compressor-turbine unit runs at almost constant maximum speed of 8700 r.p.m. for cruising conditions. The high pressure level in the cycle gives low suction volumes for the compressor. Therefore, a three-stage radial type has been provided for this size of plant. The four-stage h.p. turbine has an outlet diameter of 480mm (18·9in) and an expansion pressure ratio of 2·1 (full load). The remaining expansion with a ratio of 1·6 takes place in the power turbine with three stages located at recuperator inlet near the two-stage reduction gear. The power turbine, designed for a maximum speed of 7700 r.p.m., has a small rotor system with a maximum diameter of 620mm (24·4in) at turbine outlet.

Self-Advancing Roof Supports for Mechanised Coal Mines

ONE of the problems which has arisen with modern mechanised methods of coal mining is the provision of adequate roof-supporting means at a speed commensurate with that of the coal cutting and loading equipment. To meet this requirement the Dowty "Roofmaster" hydraulically operated, self-adjusting, roof support equipment shown in the accompanying illustration has been developed. It is for use on seams with nominal heights from 3ft to 5ft and operates in conjunction with a snaking conveyor system on a longwall face.

Two types of support built into the equipment are basically similar in design and construction. Each support assembly comprises a rigid box-section base, in which the hydraulic operating equipment is housed, and yielding hydraulic props fitted on this base support articulated top beams. A support of each type is arranged alternately along the working face. One, known as the "fore support," incorporates two props carrying a twin-section roof beam ; the other, or "aft support," has three props and a triple-section beam. The props on each type of support are hydraulically linked through a control valve for simultaneous pressurisation or release. A hydraulic jack in the front of the base of each support is mechanically connected to the rear structure of a coal conveyor situated in front of the line of supports, as shown in the illustration. The jacks of the fore supports are double-acting and those fitted on the aft supports single acting. A power pack at the gate end of the conveyor is connected through pressure and return lines and valves to the supports.

Under the operating procedure, at the commencement of a cut all the supports are in line with the jacks of the fore supports fully extended, and their roof beams set close to the face acting as cantilever supports over the conveyor. These articulated roof beams ensure the maximum possible support contact with uneven roofs and the props of all the supports are arranged to yield independently at 21 tons. The system thus provides a high even resistance along the entire face. As the coal loader moves along the working face the props of each fore support are released and their hydraulic jacks are then retracted to draw the supports up to the conveyor. The props are then pressurised to raise the roof beams to support the newly exposed face at a setting load which is adjustable up to 9 tons for each prop.

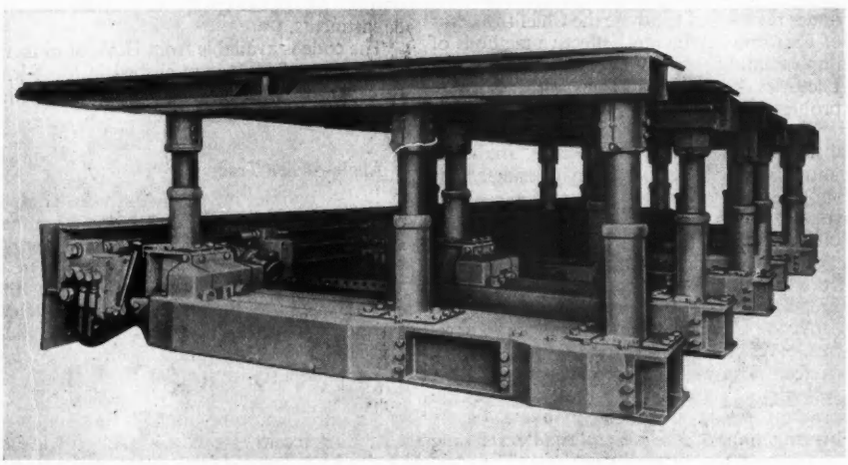
When it is required to snake the conveyor over to the new face the jack of the first fore support in the line is extended to push the conveyor forwards, whilst the support assembly is anchored by its extended props. During this movement the rams of the jacks of the subsequent supports are free to draw along their cylinders so that they offer no resistance to the movement of the conveyor structure. The props of the subsequent aft support are then released and its jack operated to draw the support up to the conveyor before the props are re-extended to support the roof. This sequence of operations is carried out along the line of supports, leaving it ready for the next series of forward movements of the fore supports as the coal loader moves along the face. Only three men are required for operating the complete support system.

The makers point out that this system, in providing a continuous support for the newly exposed roof immediately the power loader has passed, gives complete protection to face workers. Further, the use of articulated roof beams provided the maximum possible contact with uneven roofs, and the concentration of props at the waste edge gives excellent support for total caving.

Book of Reference

Water Engineer's Handbook, 1957. The Colliery Guardian Company, Ltd., 30, Furnival Street, London, E.C.4. Price 25s.—*The Water Engineer's Handbook* maintains, in its 1957 edition, its customary contents and method of presentation, the bulk of it being devoted to a directory of water undertakings. Other information includes waterworks and supply statistics, lists of the official bodies connected with the water industry, and of chief engineers and consultants employed by it, and on the Reservoirs Acts Panel. Defence regulations, relevant British standards and technical information, such as pipe data and hydraulic formulæ, are also included.

Reference to the preface will show that a fair degree of progress was made in 1956 in the amalgamation of water undertakings, and the latest details relating to it are included in the directory. Similarly, it is expected that further amalgamations will be proceeding through the present year, and amalgamations at an advanced stage when the *Handbook* went to press are also noted.



Line of self-advancing roof supports for use in conjunction with an underground coal conveyor. The supports are released, advanced and reset, by operation of hydraulic valves

Industrial and Labour Notes

Overseas Trade

In its survey of Britain's overseas trade in May, the Board of Trade describes the month as " notable on both sides of the account." Exports reached a value of £302,900,000, which was £6,000,000 above the highest figure previously recorded. But that achievement did no more than maintain the increase in value of about 7 per cent over a year earlier (excluding silver bullion repayments) which was shown in the earlier months of this year. The value of imports in May, £374,500,000, was unusually high. Re-exports were valued at £11,800,000, which was above the April figure, but rather below the average for the first quarter of this year.

The Board of Trade says that May is usually a good month for exports, though this year the figure may have been augmented a little by the delivery of goods whose completion was delayed by the engineering strike at the end of March. If April and May are considered together, the monthly rate of exports was 7 per cent higher than in the comparable period of last year. Shipments of engineering products, the growth of which had been flagging since the middle of last year, rose sharply in April and May. In that period their value averaged £117,000,000 a month, which was £8,500,000 above the monthly rate in the first quarter. Machinery other than electric was exported at a rate 5½ per cent above the first quarter's level, and aeroplane engines, tractors, machine tools and mechanical handling equipment were also exported at a higher rate than in the first quarter. Exports of scientific instruments in April and May were 21 per cent higher than a year earlier, but the value of exports of ships and boats was less than in the corresponding months of 1956. Shipments of iron and steel continued to rise during April and May, their value averaging nearly £20,000,000 a month, which was 27 per cent higher than a year earlier.

Safety in Non-Ferrous Foundries

The Ministry of Labour has now published the first report of the Joint Standing Committee on Safety, Health and Welfare Conditions in Non-Ferrous Foundries. The committee, which was formed in 1953, is composed of representatives of employers' federations, trade unions, and the factory department of the Ministry of Labour. Its function is, broadly, to keep under review and to advise the Chief Inspector of Factories on the most effective methods of implementing certain requirements of the Factories Act, 1937, and on " other cognate problems in non-ferrous foundries."

The report begins by explaining that, after discussing the terms of reference, the committee decided that its main considerations should be : the improvement of the atmospheric environment by the suppression of dust, smoke and fumes, and the control of temperature; the improvement of the appearance of foundries by cleanliness, good housekeeping, lighting and the use of colour ; the provision of better amenities and more comfortable conditions in the way of mess rooms, canteens and washing accommodation ; the reduction of accidents. The report records the progress made by the committee in its investigation of the several matters falling under these four general headings. The committee has made a number of recommendations, though it states firmly that its work is by no means completed. A technical subcommittee has organised a good deal of development work of one kind or another, which will undoubtedly lead to improvements in working conditions in non-ferrous foundries.

One particular matter emphasised in the report is that a considerable reduction in the yearly total of accidents could be brought about by better methods of housekeeping and by increased use of suitable protective clothing and other equipment, such as safety boots, spats, gaiters, goggles and eye shields. The committee's general comment, however, at the present stage of its work is that the achievement of good working conditions within the industry demands the fullest co-operation from all who work in it. There are legal obligations on both employers and employees, the committee says, but, it adds, " we look for a sense of responsibility which will lead both to devise and to use every possible means by which the standard of the industry can be raised."

Protecting X-ray Workers

A " Code of Practice for the Protection of Persons Exposed to Ionising Radiation " has been prepared by the Radioactive Substances Advisory Committee. This committee, of which Sir Charles Darwin is the chairman, was set up under the Radioactive Substances Act, 1948, to advise Ministers, including the Minister of Health, on the general problems of protection arising from the use of ionising radiations.

The code is primarily concerned with technical data relating to the necessary safeguards to ensure that adequate protection is afforded to those who work with X-ray and other radiological apparatus as well as with radioactive isotopes. The code has been designed, as far as possible, as a set of purely technical rules and is divided into two main sections. The first part contains the protection rules applicable to the use of X-rays for diagnostic purposes and to the use of X-rays and gamma-ray beam units for therapeutic purposes ; the second part contains protection rules applicable to the diagnostic or therapeutic uses of radioactive isotopes either sealed or unsealed. There is also a supplement to the code giving the relevant fundamental and scientific information for the guidance of those concerned, and technical details about the design of radiological and radio-therapy departments.

The code is available from H.M. Stationery Office, price 8s. It is published in loose-leaf form so that it can be kept up to date in the light of new knowledge.

Anglo-Soviet Trade

A booklet on " Anglo-Soviet Trade " has been prepared by the London Chamber of Commerce, to give guidance to prospective exporters and importers. It contains a great deal of useful information, including the Kabanov and the Bulganin-Khrushchev " shopping lists," details of the United Kingdom's trade with the U.S.S.R., and a list of foreign trade organisations of the U.S.S.R.

An introduction to the booklet points out that the recent growth in Anglo-Russian trade has aroused the interest of many business men who have never before ventured into this field. The account of the prospects and methods of Anglo-Soviet trade which the booklet gives is expressed, as the Chamber puts it, in " cautious terms," but it is urged that, even if the trade itself remains small in relation to world trade, it can be well worth while and " an eye should therefore be kept on developments."

Single copies of the booklet cost 5s., but for quantity orders the price is reduced. The booklet is published by the London Chamber of Commerce, 69, Cannon Street, London, E.C.4.

Fire Protection

The annual report of the Fire Protection Association shows that in 1956, for the first time since 1949, fire losses, although amounting to £27,512,000, were lower than those of the preceding year. There was thus shown, the report adds, a welcome reversal of the tendency for fire losses to rise annually from a figure of £12,047,000 in 1946 to £27,645,000 in 1955. The report comments that although the persistent rise in these figures may possibly be attributed to the depreciation of sterling rather than to a greater amount of fire damage, the volume of damage remains disturbingly large.

The report says that the Association is intensifying its endeavours to arouse public interest in fire protection. It takes the view that there is a great deal of information on fire protection methods of which adequate use is not being made. In its technical work, the Association is stressing the importance of studying industrial hazards.

Women in Industry

The Parliamentary Secretary to the Ministry of Education, Sir Edward Boyle, said, in a speech at Southend last week, that unwillingness on the part of girls to become scientists might be due in part to the feeling that science and technology were dirty jobs ! It was quite untrue, he added, for much of the work involved simple first-class brain power, research and the ability to concentrate.

Our present-day industrial society, with its high stable level, Sir Edward continued, meant that there was a far wider range of jobs open to women, yet the number of girls in universities was only one-third the number of men. There were only a quarter as many girls as men in the science departments of universities, while in technological departments there were still fewer, about 100 women, compared with 5000 men, in the academic year 1954-55. For every sixteen boys who took full-time university level courses, there was only one girl, and the boys and girls released by employers for part-time day courses were in the proportion of seven to one. These figures, Sir Edward commented, suggested that there were pretty big resources which remained untapped.

A two-day conference to discuss careers for girls in engineering is being arranged by the Women's Engineering Society. It will be held at the City of Coventry Training College on Saturday and Sunday, July 13 and 14, and it is expected that representatives of industry, the youth employment service, schools, technical colleges and universities will be present, together with members of the Women's Engineering Society. At the three main sessions of this conference, the subjects to be considered are : technical education ; industrial training, and professional achievement.

The Zuider Zee Reclamation

No. I

On May 28, celebrations were held in Holland to mark the twenty-fifth anniversary of the closure of the Zuider Zee's enclosing dam. The dam is 20 miles long and is illustrated on the right. Its completion transformed the Zuider Zee into a tideless fresh-water lake, known as the Ijsselmeer, from which several very large polders have since been reclaimed. This work is still in progress. We give below a brief account of the history of the whole project, which will be followed in No. II by some more detailed information about the Eastern Flevoland polder, reclamation of which is now well advanced.

EVEN though the scale on which the world's largest civil engineering projects are conceived has grown since the war years, and very large schemes of various kinds are now more common, the Zuider Zee reclamation still retains its place amongst the most ambitious civil engineering achievements of the world, and it remains unique compared with other land reclamation projects. Two polders of the scheme have been completed, one is almost drained, and two more have still to be reclaimed ; but it is twenty-four years since work was completed on the enclosing dam, and the general plan of the whole project was formulated, and has subsequently been modified only slightly, in 1891.

It is thought that the Zuider Zee was formed at about the end of the thirteenth century. Prior to that time, the sand dunes of the Dutch coast extended towards Denmark, protecting an area of lakes and marshland behind them from the sea. But the sea broke through, most probably on some similar occasion of storm and tidal surge to that which caused the disasters in 1953, and the Zuider Zee was formed. The earliest reclamation works in the Netherlands date from about that period, but were on a limited scale until the beginning of the seventeenth century, when the invention of the windmill made possible the drainage of comparatively large lakes and the day-to-day drainage of comparatively larger low-lying polders. This work was carried through at a time of prosperity, when money for investment in such work was available. The oldest known project for draining the Zuider Zee was put forward in this period. It dates from 1667, and is due to Stevin.

The plan of 1891 was the work of the late Dr. Lely, who is given credit in the Netherlands for inspiring the present work and seeing it actually carried into practice. Lely's reports on the reclamation stressed that the Zuider Zee should be impounded between Wieringen (then an island) and Friesland, on the line where the dam now stands. He pointed out that the reclamation of the Waddenzee—the shallows between the dam and Texel and Vlieland islands and also of the Lauwerszee—which is to the east of the Waddenzee—should be considered as separate projects. Some earlier schemes had proposed taking in these areas ; or alternatively, one scheme envisaged draining only the southern half of the Zuider Zee, and another allowing the River Ijssel to flow freely to the sea at the Marsdiep.

Lely's plan offered the advantage of first building an enclosing dam, so that subsequent reclamation would be in a tideless lake ; further, the maintenance of many miles of sea dykes would then be obviated, since they would be replaced as a first line of defence by the enclosing dam. The Waddenzee, outside the dam, was largely a sandy area, less attractive for reclamation than the predominantly clayey area within. One further point of great importance was the exclusion of salt water from such a large area ; this topic we refer to again later on, but was doubtless a major consideration at the planning stage. The enclosed lake was then to be reclaimed in four stages. The four polders thus formed would reclaim about two-thirds of the lake, leaving the deepest area, which happened also to be sandy in character and hence potentially the poorest land, as a fresh water reservoir.

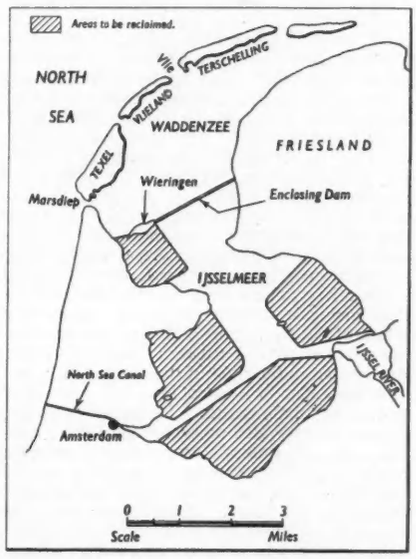


Fig. 2—Lely's proposals for the Zuider Zee reclamation

Fig. 1—Sluice gate structures at Den Oever. There are three sets of five sluices

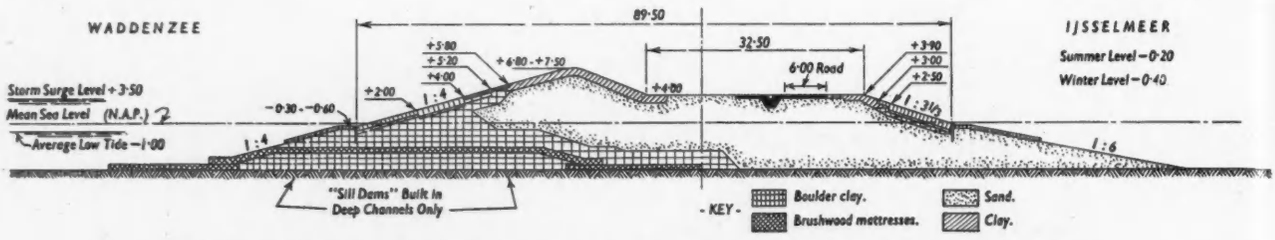


Fig. 3—Typical cross section of the enclosing dam. Various kinds of stone pitching protect the slopes between tide levels

The main modifications since made have been in the layout of the southern polders, one of which is being built in two stages. It is this part of the work which is still in progress and is described in the concluding section of this article. The scheme is shown diagrammatically in Fig. 2.

The Enclosing Dam

Floods in 1916, and food shortage in the first world war appear to have been the incentives which led to the decision to go ahead with the Zuider Zee works, which was taken in 1918, even though Lely's plan had been officially approved in 1892. Preparations and research were then initiated, and a start on the 1½-mile length of dyke connecting the mainland with the island of Wieringen was made in 1920, and the dyke was completed in 1924. The nineteen-twenties were, however, lean years economically, so construction of the main dyke was not carried out until the period 1927–33.

Following this structure through from the mainland to the Friesian coast, there are the following: 1½ miles of dyke to the former island of Wieringen (which is now joined to the mainland by the Wieringermeer polder); traversing the former island, we come to Den Oever and the harbour which was built for servicing the constructional work. The harbour enclosures are extensive, with an inner and outer harbour on the seaward side of the dam, with a channel passing landwards, with a swing bridge, and a lock, capable of taking ships up to 2000 tons, giving access to the southern harbour and the Ijsselmeer.

Immediately beyond the swing bridge are the Stevin sluices, comprising three sets of five sluiceways, for controlling discharges of fresh water from the Ijsselmeer. The appearance of these sluices from the roadway is shown in Fig. 1. They are massively built, each passage being closed by a vertical-lift gate weighing 40 tons, and measuring 12m wide by 6·9m high, which can be operated electrically or by hand. The gate is duplicated in each opening, front and rear gates moving in the tower-like housings shown in the illustration. As a further safety measure, a pair of tidal flap gates is built into the sluice culvert, where it passes under the roadway, thus giving a positive protection against the inflow of salt water, even if both of the main gates are not operative. Further, a "stoplog" gantry can be seen to the right of the illustration; steel bulkheads can be floated into any opening to close it for maintenance. Extensive scour protection was provided on each side of these sluice channels, by sinking large willow mattresses loaded with stone, and on the seaward side, an "island" breakwater shelters the area into which the sluices discharge. The concrete structures here are not piled, but have a raft foundation. Two similar sets of five sluices—the Lorentz sluices—are situated at the other end of the dam at Kornwerderzand, making twenty-five sluices altogether.

Past the three sets of sluices at Den Oever, there is next a wide area of reclamation, which at the time of construction formed part of the cofferdam within which the sluices were built. The main dam extends 18½ miles from this point across to Friesland. Several miles along it is a monument—a white tower—marking the place where the closure was made in 1932, the twenty-fifth anniversary of which event was celebrated last month. In about the middle of the dam is a harbour. This was constructed at an early stage of the work to service floating plant and was an essential facility during the period of construction. On the Friesland coast there are, as already mentioned, two sets of sluices, and there is another harbour and a swing bridge, and two locks giving access through the dam to ships of 2000 tons and 600 tons respectively.

Although it is unique in scale, the enclosing dam is in other respects typical of Dutch work of this kind. Fig. 3 illustrates its construction. Local materials were used with the exception of the stone, which is generally basalt, the high specific gravity of which is advantageous in all works of this kind, and justifies importing it from Germany or Belgium. The shallower lengths of the work were selected for the earlier dam construction, so that tidal scour would be minimised for as long as possible. Later on, however, "sill-dams," formed of boulder clay covered over with large willow mattresses weighted with stone, were built in the deep channels to limit their depth to about −3·5m below sea level. Tides were passed through the open sluices in the later stages of work, until the dam was closed.

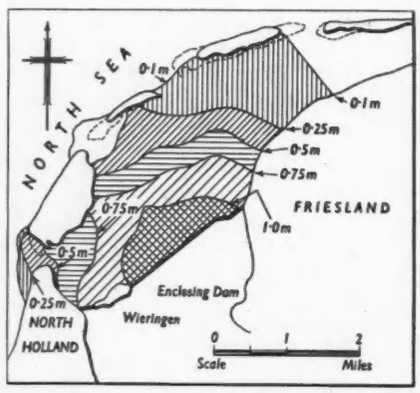


Fig. 4—The Lorentz commission's prediction for increases in maximum storm surge levels due to the enclosing dam

The Lorentz Commission

Tidal movement through the dam, as its construction proceeded, and in particular in the final stages before closure, obviously had considerable bearing on the hazards of the work. Furthermore, the effect of the finished structure on the tides needed to be determined. Investigations aiming at a quantitative appraisal of these problems were carried out by a royal commission, whose president was Professor Lorentz. The commission's work was complicated, but was carried through to a successful prediction of the modified tidal movements, and is cited in the Netherlands as a classical example of scientific investigation. Very briefly, the results were as follows. The full tidal range was not experienced in the Zuider Zee. Tides flowed in from the North Sea principally through the Marsdiep and the Vlie, but due to phase difference only reduced tidal currents penetrated to the southern end. However, a circular current was also produced by this phase difference. At the site of the dam these currents were of no significance in the shallows, but only in the deep channels; hence, the constructional procedure mentioned earlier. Critical conditions in the gaps, as building progressed, would give average tidal velocities up to 12ft per second, it was computed, and up to 20ft per second under conditions of storm and tidal surge. On completion of the work, tidal range outside the dam would normally be increased by about 90 per cent. Increases in levels predicted for storm surge conditions due to the dam are shown in Fig. 4. These results, which have since been proved accurate, were obtained by taking measurements of tidal movement, then formulating and solving equations for it.

The increased tidal levels in the Waddenzee which the dam created thus also necessitated the heightening of the sea defence embankments on the adjoining coasts and islands. The cost of the whole scheme of enclosure, including these necessary subsidiary works, was about £12,000,000. Fuller accounts of it were given in a lecture by Dr. V. J. P. Van Kuffeler, who was at that time the director of the works, at the Institution of Civil Engineers on March 2, 1933, and in The Engineer of August 9 and 16, 1929. The enclosing dam was inaugurated on September 26, 1933.

Benefits of the Enclosing Dam

Because agricultural land was scarce, it was decided to go ahead with reclamation of the first polder—the north-west or Wieringermeer polder—at the time that construction of the enclosing dam was in progress. Previously a small experimental polder had been enclosed, drained and put into cultivation, to investigate

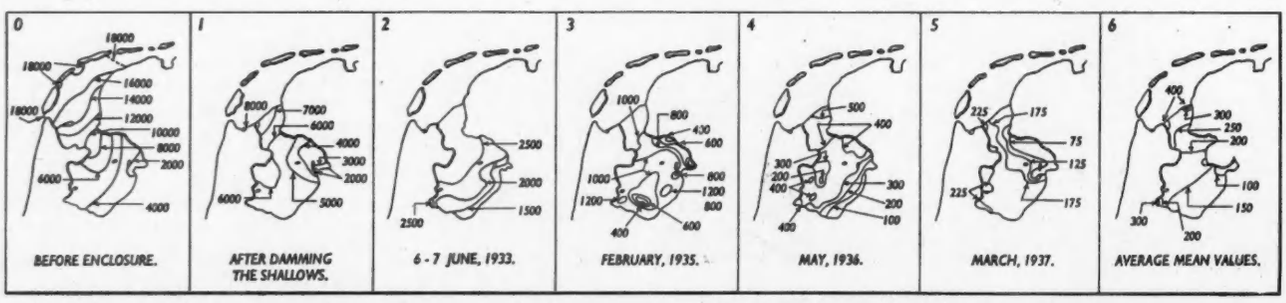


Fig. 5—Salt concentrations, expressed in milligrammes per litre, in the Zuider Zee before its enclosure, and in the Ijsselmeer at various subsequent dates

the numerous problems which had to be solved for the large-scale reclamation envisaged later on to be successful. But before describing this reclamation work a few words may be said about the benefits derived from the enclosing dam. It is taken for granted that the primary justification of this enormous structure is reclamation. It enables the polder dykes to be built in still water, and it offers a staunch "first line" of defence against tidal surges. Further, its benefit in reducing maintenance to its seaward face and adjoining dykes totalling 30 miles in length, instead of about 200 miles of dykes previously exposed to the sea, has already been pointed out. Added to this, it also provides much improved road communication to and from Friesland.

Therefore it is at first rather surprising to learn that the enclosing dam is considered to have justified itself economically, when considered as a water supply scheme. In this area, as in eastern areas of England, there are proceeding, independently, a rising of sea level and a sinking of the land. A lowering in level of newly reclaimed land, which shrinks when it is drained, is also experienced in some places. Apart from entailing heightening of coast defences, such phenomena also cause more severe conditions of pumping to drain the polders, which together with a fairly high rate of usage of water for farming and so on, encourage seepage of sea water into the reclaimed land, and eventually even its poisoning by salinity. This problem has always been particularly acute in the Netherlands, and early reclamation works, such as the draining of the Harlem mere, had the exclusion of salt as one of their main aims, to the same or even a greater extent than the reclamation of land.

In the case of the Zuider Zee, its coastline is so extensive that the amelioration of salinity, caused by excluding salt water from it, can well be seen from the map. The concentration of salt before closure and at successive stages afterwards, as the River Ijssel gradually flushed out the salt water, is indicated in Fig. 5. The small salt content still in the water is due partly to what is called by the Dutch "fossil" salt. Salt in the bed of Ijsselmeer has been leached out, but lower down there is still this "fossil" salt which is brought into the lake by drainage from deep strata.

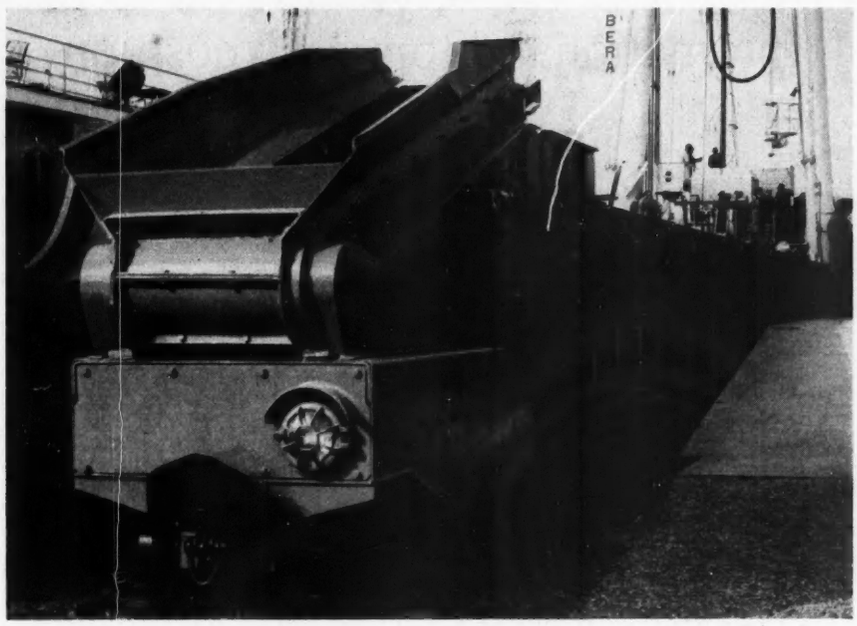
The Ijsselmeer, therefore, is an important reservoir of fresh water It is generally maintained at a level of 0·4m below mean sea level in winter, and 0·2m below in summer. In summer, of course, demands of water for the surrounding agricultural areas are much heavier, hence the higher level. One other water supply function is important. The canals of Amsterdam, which are numerous, can be flushed through with water from the Ijsselmeer, which then flows out through the North Sea Canal, and eventually through the sea locks at Ijmuiden. This is an important service, not only for the cleanliness of the city, but as a partial remedy for scouring out the salt water which is introduced whenever a ship is locked into the canal at Ijmuiden.

Discharge of fresh water through the sluices at Den Oever and Kornwerderzand is regulated according to instructions from the head office of the Zuiderzeewerken in The Hague. The hydrological service in this office is fed with water level and discharge measurements taken in the Ijsselmeer itself, and at various places on the Ijssel and Rhine rivers as far south as Düsseldorf. The Ijsselmeer can then be used most effectively as a reservoir for flood control, or for holding river flow over a period of exceptionally high tide.

The Ijsselmeer has also become an important region for fresh water fishing, and, in particular, eel fishing is now an industry of some importance there. Elvers enter the lake through the lock at Den Oever, but experiments are in hand to perfect a fish pass designed specially for elvers.

Consideration is at present being given to raising the level of the Ijsselmeer by an appreciable amount. From the proposals described in No. II, it will be clear that such a change will not affect water levels in the canals of Amsterdam or elsewhere. With this change the Ijsselmeer's various water conservation functions will be enhanced, in spite of the reduced area of the lake due to reclamation.

(To be continued)



Bunker train, 40m long, fitted with loading and main conveyor, and capable of transporting 35 cubic metres

Bunker Train for Mines

In the accompanying illustration we show a view of the Salzgitter model "BZ35" bunker train which was recently exhibited at the German Industries Fair at Hanover. The equipment is manufactured by Salzgitter Maschinen A.G., Salzgitter-Watenstedt. It is a mobile conveyor for the continuous loading and unloading of material. This is done while the train is on a straight portion of the track, although it is equally capable of negotiating points and curves with a radius of at least 20m.

The bunker train comprises principally the driving truck (at the far end of the train), the loading truck (seen in the illustration at the near end of the train), and an arbitrary number of coupled-up conveyor trucks. The drive is usually by compressed air, but a change-over to electric drive is possible.

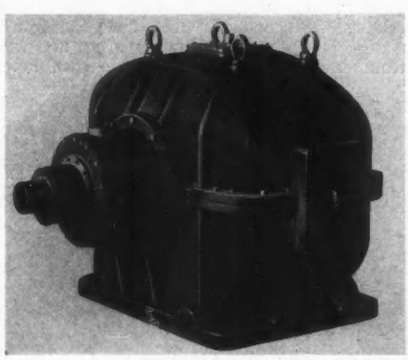
For loading, a mechanical loader is used, from which the material is transferred into the train, by the inclined conveyor seen in the illustration, where the main plate conveyor, which forms the bottom of the trucks, transfers it to the far end. A tamping device increases the amount of material which can be loaded. When full, the bunker train is pulled away by a mine locomotive, and is subsequently unloaded by the main conveyor.

The train, as shown, has a carrying capacity of 35 cubic metres or up to 60 tons. Total length is about 40m, and it can be built for the usual narrow gauges up to 915mm. A speed of 10km per hour when full or 14km per hour when empty is stated to be attainable.

Hydraulic Transmission

In the accompanying illustration we show the model "P730" oil pump, the largest of a series of radial pumps built by the Hydromechanik Division of Kieler Howaldtswerke Aktiengesellschaft, Kiel, German Federal Republic. The Hydromechanik pumps range from 3 h.p. to 730 h.p., with working pressures of 50 to 220 atmospheres, and peak pressures of 100 to 315 atmospheres. A heavy series is in preparation, and, it is stated, will be put on the market next year. This will range from 6 h.p. to 800 h.p., with almost identical overall dimensions, but with higher oil flow and larger working pressures.

The model "P730" is designed for hydraulic transmissions, and possesses a rotating cylinder block with radial cylinder bores, which is driven by a prime mover. The pistons are fitted with rollers which bear against eccentrics which surround the cylinder block. These eccentrics are rotatably mounted in a support, the position of which relative to the cylinder block centre can be altered. In this way the piston stroke and, hence, the oil output, can be varied which, in turn, causes a speed variation in a second pump



Model "P730" oil pump

connected as a hydraulic motor. The pump is characterised by the large number of pistons, the design of the central pinion, and the oil connections to the rotating cylinder block. Like all radial piston pumps, it is not suitable for working in an oil bath. A reduction gearbox is flanged on so that a variety of electric motors can be used. The change from maximum to minimum oil output and vice versa can, it is stated, be made in as little as 0·1 to 0·2 seconds.

First Flight of Ram Jet "Griffon 02"

It is announced that the single-seater experimental plane Nord 1500 "Griffon 02," built by SNCAN, carried out its first flight with ram jet ignited on April 26. This is stated to be the first time that an aircraft equipped with a combination turbo-jet/ram jet power unit has flown after taking off under its own power. The aircraft, which was piloted by Monsieur André Turcat, is fitted with one SNECMA "Atar" and one SNCAN ram jet.

International Atomic Exposition at Philadelphia

BY OUR AMERICAN EDITOR

(No. IV—*Concluded from page 967, June 21*)

The third International Atomic Exposition was held at the Convention Hall in Philadelphia, Pennsylvania, from March 10 to 15, in conjunction with the second Nuclear Engineering and Science Congress. The exhibition was organised under the sponsorship of the American Institute of Chemical Engineers in co-operation with four other engineering institutions and was attended by some 10,000 visitors. It presented a comprehensive picture of the current state of development in the application of atomic energy in American industry, and this article reviews certain exhibits of particular interest.

General Electric Company

A PANORAMIC model, which is shown in Fig. 16, was exhibited by the General Electric Company, Schenectady, New York, to illustrate the Dresden atomic power station to be constructed by the firm at a site 47 miles south-west of Chicago for the Commonwealth Edison Company. The 200ft sphere will house the General Electric dual-cycle boiling water reactor and a turbo-generator. The 180MW plant at present is the largest all-nuclear power station planned in the United States and will be completed by 1960. The dual-cycle boiling water reactor was selected as the best solution to fulfil the design requirements in this particular case, although other methods were considered. The dual-cycle boiling water reactor, as developed by General Electric, is a modified form of the direct boiling cycle which was pioneered by the Argonne National Laboratory. The dual-cycle approach is to remove as much energy as possible by boiling in the upper part of the reactor without exceeding the limit of reactivity for good stability. A simplified flow diagram of this cycle is shown in Fig. 18. The boiling portion is controlled by the degree of sub-cooling at the inlet to the reactor. To accomplish this, the steam-water mixture is sent to a separating drum and the steam, essentially at reactor pressure, then flows directly to the turbine. The saturated water flows from the drum through heat exchangers where some energy is removed to produce steam at a somewhat lower pressure. This secondary steam is admitted to a lower stage of the turbine. The fraction of energy removed by means of the heat exchangers controls the temperature of the water returned to the reactor.

The load response is expected to be good. The pressure in the reactor is held constant by the turbine regulating valve which controls the primary steam rate. Load changes are met by actuation of the secondary admission valves by the turbine governor. Decreasing the rate of secondary steam production results in higher temperature water returning to the reactor. This decrease in sub-cooling causes the reactor output to drop. For an increase in load, the reverse procedure is used. This self-regulating control feature causes the pressure in the secondary system to vary with load. As would be expected, the heat rate of the dual-cycle is contingent upon the primary steam pressure and the percentage of power which is removed as primary steam.

Fig. 16 shows the general arrangement of the reactor building. The reactor and its auxiliaries are installed in a sphere with the turbo-generator and its auxiliaries in a turbine building external to this sphere. The major items of equipment in the reactor building are the reactor vessel, the primary steam drum, secondary steam generators, the recirculating pumps and the main biological shielding. The turbo-generator set, the control room, demineraliser equipment and the usual turbine room auxiliaries are in the turbine building. Sufficient compartmentation for major items of equipment, or groups of equipment, is provided so that maintenance can be performed by direct contact during the operation of the remainder of the plant. Sufficient biological shielding is provided to allow limited access to the reactor and turbine buildings during operation for observation and inspection. The fuel handling and storage building is situated adjacent to the reactor building. It is connected to the reactor building by an underground canal and a discharge tube which may be isolated from the exterior when not in use.

Argonne National Laboratory

The display of the Argonne National Laboratory, Lemont, Illinois, emphasised the Experimental Boiling Water Reactor (EBWR) which recently went into operation at Lemont. A detailed description of this atomic power station appeared in our issues of April 19, 26, and May 3. For some time this laboratory of the A.E.C. has been particularly concerned with the reprocessing of nuclear fuels, and an interesting account was presented at the Philadelphia Congress by A. B. Shuck, of Argonne, on the fabrication of irradiated reactor fuels by semi-automatic remote-controlled equipment. The approach taken by Argonne involves a reduction of fuel inventory costs by the reduction or elimination of the cooling period required prior to processing and the reduction of the high costs of the chemical decontamination process. It was, therefore, proposed that the fuel be processed only to remove the irradiation damage of each cycle through the reactor and not to decontaminate the reactor fuels sufficiently for conventional fabrication. The pyrometallurgical processes for the partial removal of fission elements have already been described in the literature. The processed and reconstituted metal produced by these pyrometallurgical processes is then refabricated into reactor fuel elements.

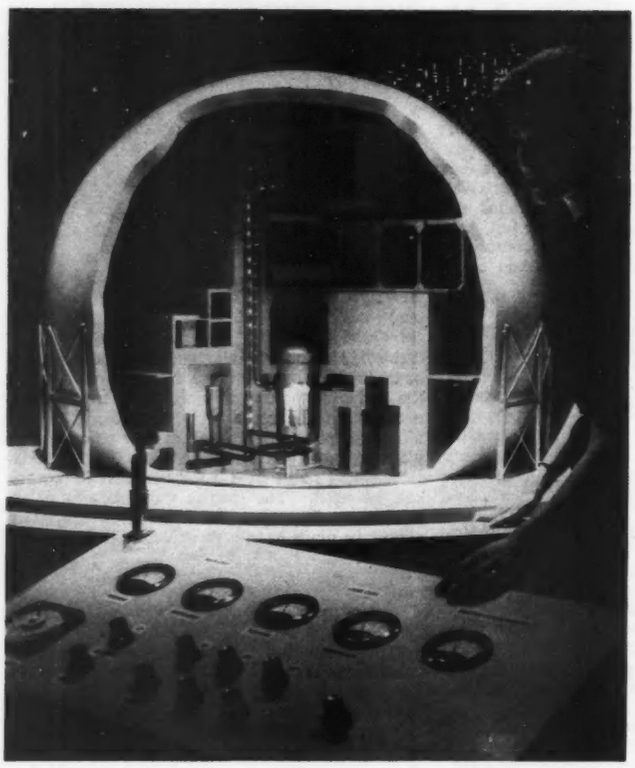


Fig. 16—Panoramic model of 180MW nuclear power station being built by the General Electric Company for the Commonwealth Edison Company in Illinois

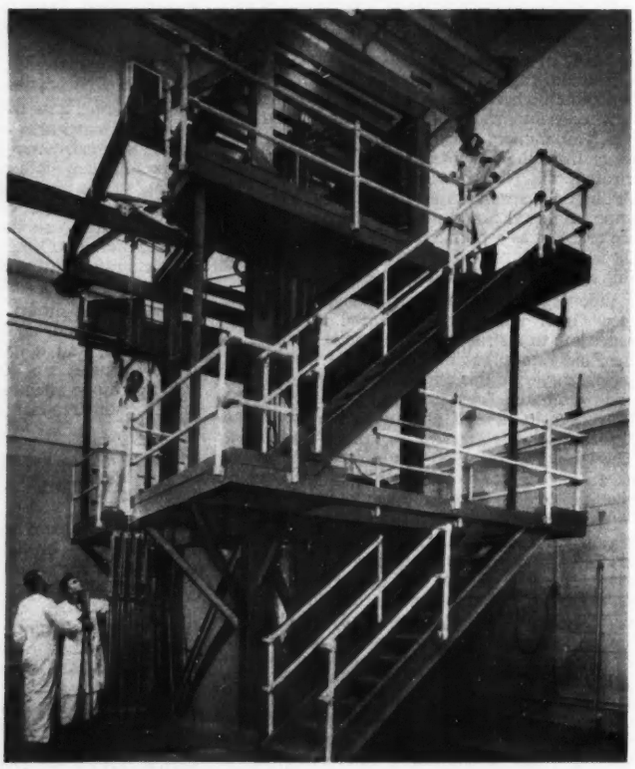


Fig. 17—Experimental nuclear core assembly of Consolidated Edison reactor being assembled at the critical experiment laboratory of the Babcock and Wilcox Company

Each gramme of a typical fast reactor fuel, cycled at approximately 1½ per cent burn-out and cooled for fifteen days before reprocessing, will radiate gamma-rays approximately forty times as intense as 1 curie of radon. Pyrometallurgical processing may reduce this level to one-third or one-quarter, but if reasonable batches are to be processed, these are extremely intense radiation sources. It has been calculated that the radiation 1m from a 10 kg batch of this fuel will have an intensity of between 10^6 and 10^7 roentgen per hour. It is estimated that the average background radiation within the work areas of a process cell handling this material will be of the order of 10^5 to 10^6 roentgen per hour with local zones of much more intense radiation.

These high radiation levels must be considered in the design of process equipment for operation within the process cell. Organic materials such as rubber, neoprene and polyethylene, are damaged at from 10^7 to 10^8 roentgens and would last only a few hours in a process cell. Plastics seals on vacuum equipment, bearings and gasketing for pipes and vessels must, therefore, be avoided or provision must be made to replace them at intervals not exceeding that for minimum damage. Lubricating oils are damaged by from 10^8 to 10^9 roentgens. Provision must be made to pump the oil through the bearings or, where grease is used, the bearings should be designed so that incoming grease flushes out the old grease. Unfortunately, certain of the components of oils and greases tend to cross-link and to harden, while others are cracked to volatile substances and give a particular problem in the lubrication and sealing of mechanical vacuum pumps. Therefore, equipment to operate in the immediate vicinity of the process material should be designed to work without lubrication or with a dry lubricant.

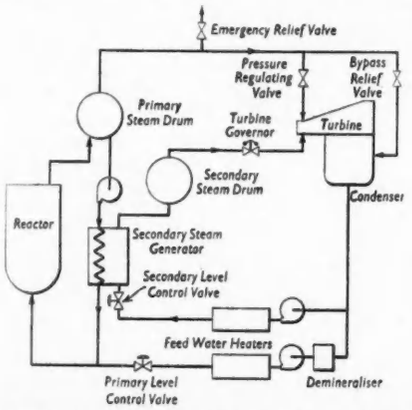


Fig. 18—Flow diagram of 180MW General Electric atomic power station

It has been found that even the best non-browning optical glass will lose its transparency in short periods of time. Optical systems exposed immediately to the fuel as for inspection periscopes and microscopes should employ mirror optics. Conventional electrical insulation will be damaged in a few hours in the high radiation environment.

Mineral-insulated conductors using a compacted magnesia insulation in a drawn copper or steel jacket are satisfactory, provided a way may be found to pot the ends without the use of organic materials. Conventional electrical motors are not satisfactory unless they can be shielded. It is believed that the new American N.E.M.A. Class "C" motors will be satisfactory from the radiation standpoint. Some experimental work has been done in the design and construction of electric motors and transformers using aluminium conductors with a heavy anodised coating insulation. The use of this construction for radioactive environments is being examined at Argonne.

The atmosphere in the process cell will be highly ionised and is no longer a good dielectric. Difficulties may be expected with switches, commutators and sliprings from sparking and corona effects. These difficulties may be avoided in the use of electric motors of multi-phase induction construction. Corona-like effects have been seen at much lower voltages than will be apparent in air. Very preliminary experiments at 10^6 roentgen per hour have indicated that it may not be possible to operate the electrical equipment at 440V although both 220V and 110V operation appears to be satisfactory. Because of the higher ionisation potentials, helium gas may be preferable to argon gas as the inert process cell atmosphere.

A continuous purification of the atmosphere was found to be necessary to compensate for the air introduced with materials and for minute leakage into the system. Oxygen may be removed from argon by catalytic reaction with hydrogen and adsorption on driers. The argon may be purified of the other gases by liquefaction and fractionation. Helium gas may be purified by adsorption of the oxygen, nitrogen and other gases upon activated carbon or upon another adsorber, such as silica gel, alumina or the synthetic zeolites. The adsorption is carried out either at temperatures approaching that of liquid air and at atmospheric pressure or at an increased pressure and at normal refrigeration temperatures. The adsorption processes may be made regenerative so that none of the adsorbing material is used up. The total of impurities in the helium may be reduced to below 100 parts per million by the adsorption method. Safety requires that the process cell be operated at a slight negative pressure with respect to the room atmosphere. Any air leakage through small openings will therefore be inward. In order that the purifying system need not be too large, the process cell must be made as nearly leaktight as possible. This leads to special design requirements in the sealing of conductors and services through the cave walls, in the sealing of windows and in the design of manipulators, transfer locks, plugs and doors in the process cells.

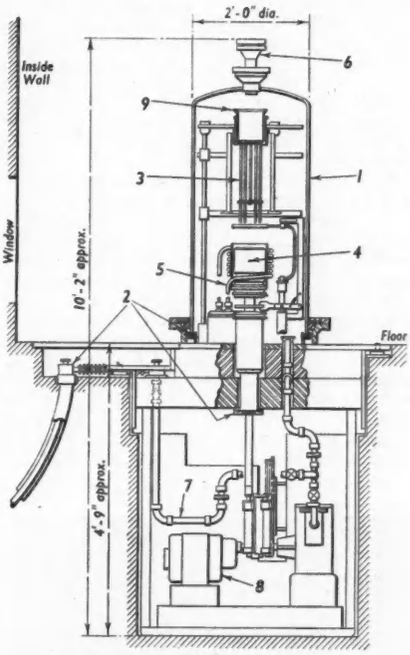
The above considerations have been applied at Argonne recently in developing equipment for the remote refabrication of fuel pins or rods for the Experimental Breeder Reactor II. The fuel for this reactor is in the form of cylindrical rods, 0·144in±0·001in in diameter and 14·22in long. They are enclosed in stainless steel tubes with a 0·004in annulus between the fuel rod and the tube filled with sodium metal. After irradiation the pins are removed from the tubes and pyrometallurgically processed to remove the volatile and more easily oxidised or slagged constituents. The equilibrium alloys after processing will contain the following fission elements in quantities greater than 0·01 per cent :—

Element	Per cent
Zirconium	0·10
Niobium	0·01
Molybdenum	3·42
Technicium	0·99
Ruthenium	2·63
Rhodium	0·47
Palladium	0·30
Total	7·92

This composition as a uranium base alloy was found to be hard in the as-cast condition (46 to 48 Rockwell C). It cannot be worked in the range of 300 deg. to 600 deg. Cent. as can uranium. It can be reduced by rolling at 800 deg. Cent. Above this temperature the metal appears to be somewhat hot-short.

Several methods were considered for the fabrication of this fuel. Conventional wire fabrication involving the casting of ingots, rolling, annealing, swaging and drawing through dies was ruled out because of the lack of ductility and the large number of process steps and the amount and complexity of the equipment required. Powder metallurgy was considered because it is the more or less traditional method of handling complex alloys and hard or brittle compositions. However, the laboratory staff looked with distaste at the prospect of having to handle many kilogrammes of thermally hot, explosively pyrophoric, intensively radioactive metal powder in the process cells. It was apparent at this time that a fresh approach to the problem should be made. Precision casting was selected as the method of greatest promise for development. The method proposed was a simplified non-mechanical injection casting process using the pressure of either helium or argon together with the inertia effect of the moving metal to fill the evacuated mould. This method was as follows : (1) a shallow crucible of metal is melted under vacuum in a vacuum pressure furnace. A cluster of tubular moulds, with the top ends closed, is suspended above the crucible in such a manner that the sprue or gate ends are pointed down toward the metal bath. (2) The crucible is raised immersing the lower ends of the tubes in the liquid metal bath and the furnace is simultaneously pressurised with inert gas to several atmospheres. (3) The gas pressure forces the molten metal into the mould cavities. (4) The filling of the cavities is further implemented by the ram inertia effect of the molten metal as the mould is filled.

A schematic drawing of the equipment designed for this operation is shown in Fig. 19. The furnace chamber consists of the metal bell which is sealed to the furnace bottom by means of a solder freeze seal. It is held against the internal pressure by a cam-acting clamping ring. The furnace chamber is designed to withstand an internal pressure of 11 atmospheres. It is mounted on a 12in thick shield block which rests in a recess in the process cell floor above a shielded pit area. The crucible is mounted upon a vertically acting ram, which in its lower position centres the crucible in a solid conductor induction coil and which may be raised to either of two positions above the induction coil by the action of a double slide pneumatic cylinder assembly situated below the shield block. The ram acts as a solid shielding plug where it passes through the shield block. It is vacuum-sealed below the shield where it is protected from the direct exposure to radiation. The shielded pit area houses all equipment of questionable radiation resistance including the vacuum pumps, electrical components, solenoid-operated valves, accumulators, lubricated gear reducers and other equipment requiring organic or radiation-sensitive materials. This equipment is mounted on a frame which is attached to the bottom of the shield block and is lifted out of the pit with the shield block for servicing or maintenance. The equipment pallet disengages from the supporting frame and each item of equipment may be lifted free by the operation of simple cam keys.



1—Furnace bell.
2—Quick-melting metallic seals.
3—Mould tubes.
4—Crucible.
5—Induction coil.
6—Safety head.
7—Gas pressure line.
8—Vacuum pump.
9—Standard lifting ring.

Fig. 19—Schematic arrangement of vacuum injection casting furnace for fuel rod manufacture developed at the Argonne National Laboratory

The moulds are non-permeable refractory tubes closed at one end and suspended, open end down, above the crucible in a fixture which can hold a maximum of ninety-nine of the rods. The zone of the furnace holding the mould tubes is

independently heated by a resistance heater. The moulds are shielded from direct heat radiation from the crucible by a tantalum shield which automatically swings out of the way as the crucible is raised. Power for melting is supplied by a conventional h.f. generator outside of the shielded area to the induction coil around the crucible assembly. The charge is melted under high vacuum as supplied by a modification of a conventional high vacuum pumping system. Since the moulds are within the vacuum chamber, they are also evacuated. Provision is made to valve off the high vacuum system immediately before pouring and to maintain the furnace vacuum by means of the mechanical pump alone. Pressure is supplied from an accumulator tank connected to the system by large tubulation. A two-way selector valve connects the furnace either to the mechanical pump or to the accumulator tank. The accumulator tank is sized to give a final pressure in the furnace of approximately half the initial pressure in the tank. The excursion of the ram upward raises the molten metal level above the lower end of the tubes and trips a snap switch which moves the selector valve from the vacuum system to the pressure system. The sudden increase in pressure forces the molten fuel alloy up into the mould tubes where it freezes in the form of the shape of the tube bore.

Two designs of moulds have been investigated. The first mould consists of precision bore, high silica glass tubes coated on the inside with a colloidal graphite wash. They are commercially produced as precision bore tubing with a bore tolerance of ±0·0005in. "Vycor" tubing has the disadvantage of low resistance to mechanical shock and the pressure and temperature of metal must be very closely controlled to prevent the bursting of the tubes as the metal is rammed into them under its own inertia. The colloidal graphite wash serves to separate the metal from the silica. Where the wash coating is imperfect, a reaction layer forms between the silica and the metal which causes a slight roughening of the surface of the casting. Where the coating has been applied uniformly, the cast surface is extremely smooth and glass-like. Tolerances of ±0·001in on the diameter have been produced in approximately 96 per cent of the castings.

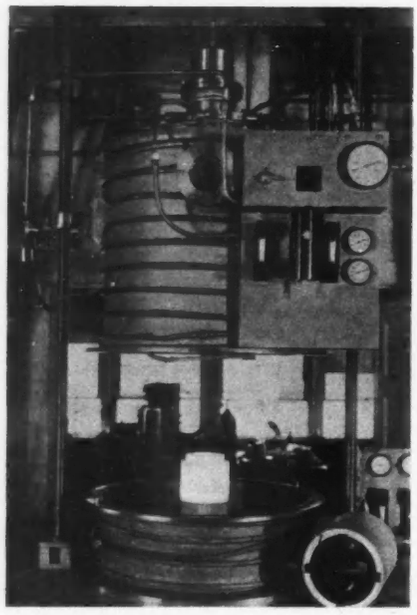


Fig. 20—Prototype furnace equipment installed at Argonne to test gas pressure injection casting

Fig. 20 illustrates the prototype equipment used to test out the principles of gas pressure injection casting. This equipment was assembled from some existing furnace and vacuum system components, but, nevertheless, produced acceptable castings. The photograph shows the furnace open with the crucible in the lower position. The cooling coils will not be used on the in-cave furnace nor will the O-ring gaskets. The glass moulds were held in a special fixture which was set up to hold both 0·144in bore and 0·384in bore tubes. Recent tests have eliminated the bulbs at the top end of the tubes, using instead a flattened closure. The fixture is inserted in the top chamber of the furnace, where it is suspended within a resistance heater to allow the pre-heating of the moulds. Castings have been made by the gas pressure injection casting technique (1) in uncoated glass moulds, (2) in glass moulds coated with magnesium zirconate wash and (3) in moulds coated with colloidal graphite wash. The material cast was uranium at 1340 deg. Cent. and the mould temperature was 450 deg. Cent. and the pressure was 45 lb per square inch absolute. Somewhat better surfaces were attained with the graphite coated moulds than with the magnesium zirconate coated moulds. Very poor surfaces and short length castings resulted from the unwashed moulds.

Fig. 19 indicates many of the provisions designed especially for hot cell work. All of the major sub-assemblies of the unit come apart without the use of bolts or nuts. The equipment is disassembled by straight vertical movements so that it can be taken apart by the overhead crane and manipulator equipment. The furnace bell is convection-cooled and designed so that its temperature will not go above 200 deg. Cent. during a normal cycle. This eliminates the added complications and hazards of water cooling in the process cell. Electrical connections are made by removable bridge bars between a fixed section of the cell floor and the removal shield block. Gas connections are made by a somewhat similar arrangement utilising freeze seal fittings or self-soldering connections. The electrical and service connections are recessed into the cell floor and covered by a floor plate so that they are both protected and are out of the way. The auxiliary equipment is shielded and placed below the furnace bell in the pit area where it is out of the direct radiation and where it allows a clear theatre of operation for manipulator work about the furnace. In the fixture to be used, the ninety-nine castings are arranged within a 4¼in diameter holder. The minimum thickness of the "Vycor" tubes has been determined so that the total heat capacity of the glass tube will be sufficient to cause the metal to drop to a temperature of approximately 1050 deg. Cent. and to absorb the heat of solidification. The calculation of the heat generated and the thermal losses from this casting array indicates that the centre castings will reach an equilibrium temperature between 650 deg. and 850 deg. Cent. if forced cooling is not provided. Forced cooling will be supplied by circulating the pressurised furnace atmosphere downward across the tubes and up over the furnace shell. Counter-convection circulation is used to prevent transfer of the heat from the hot crucible to the fuel castings. The furnace operation will be a batch operation, and the charge preparation, loading and unloading of the furnace will be by means of a manipulator.

After cooling, the castings, while still in their tubes, will be transferred to an unloading machine, where the castings will be lined up in a row on an inclined tray feeder spreading them out in a two-dimensional array. This both reduces the absorption of gamma-rays and increases the thermal loss by radiation so that the castings will cool down to a temperature slightly above the ambient temperature. The feeding device will transfer the pins one at a time between two concave, roughened rolls, which break the glass into small fragments away from the castings. The castings will then move out beneath an inspection periscope, where it will be noted whether the glass is fully removed and whether malformed castings have been produced which will interfere in subsequent operations. A selector device will be operated from outside the cave and will move the castings either to the scrap chopper or on to the cutting operation. The castings pass into the spindle of a double-collet lathe. This lathe is designed with two vertical carriages, which will notch the casting at each end with two circumferential notches exactly 14·22in apart. Pressure rolls will be brought to bear against the ends of the castings beyond the notches as rotation is continued, causing the casting ends to be broken. They will fall into a collector tray, which will save the salvage ends and the chips formed by the notching operation. It is believed that the rods can be fractured to length with sufficient accuracy that it will be unnecessary to face the ends. However, a slight change in the tooling and in the operational sequence of the lathe will allow the pins to be faced to exact length, but this is at the expense of the production of metal turnings. It is probable that only a few rods of each batch will be faced and the turnings will be collected for chemical analysis. After facing, the castings will be moved by the transfer device to the inspection station, where they will pass through pneumatic gauging devices measuring their diameter and length, across the suspension of a semi-automatic balance, where they will be weighed to the nearest 10 milligrammes and finally under a reflection optics periscope, where the surfaces will be inspected for porosity, laps or other conditions which will interfere with liquid metal bonding. This inspection will be done in the transfer device, which will pass the fuel rods slowly below the inspection periscope rotating it as it is passed. The fuel element castings will then be inserted into a rotary magazine transfer fixture, which will feed the tube loading machinery for the jacketing and bonding operations.

Babcock and Wilcox Company

The principal scheme illustrated and described at the stand of the Babcock and Wilcox Company, New York, was the atomic power station which the firm is to construct for the Consolidated Edison Company, of New York, at Indian Point on the Hudson River some 24 miles north of New York City. The reactor will be a pressurised water design and will be the first commercial American unit to use thorium as the fertile material to supplement the base fuel uranium 235. The heat from the reactor would produce 140MW of electric energy if it were not superheated. However, the saturated steam leaving the reactor will be superheated in separate oil-fired units, resulting in a total capacity of 236MW, in an appreciable decrease in the cost of the plant per unit of capacity and in a substantial decrease in the plant heat rate.

The nuclear electric generating station will be built on approximately 350 acres of land. Considering the heavy population density of the greater New York metropolitan region in general, the area is relatively sparsely populated. There are no residences or industrial works within a one-quarter mile radius of the proposed plant. The heat balance diagram for the station is shown in Fig. 21. The feed water heating system consists of four stages with three closed feed water heaters, followed by a deaerating heater for the removal of oxygen. The heat rate for the steam cycle exclusive of reactor efficiency is 10,700 B.Th.U. per net kilowatt-hour produced. The general layout of the plant follows the general arrangement used for the

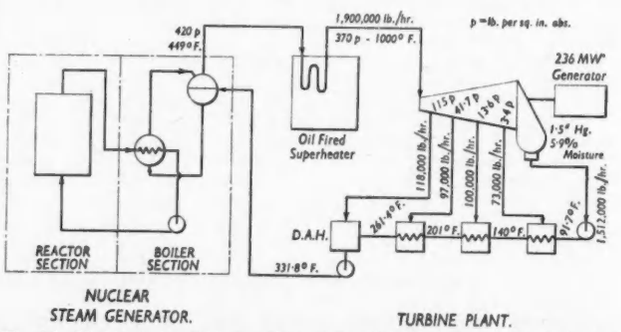


Fig. 21—Heat balance diagram of the Indian Point atomic power station of the Consolidated Edison Company

company's conventional steam power stations, with the nuclear reactor replacing the conventional boiler. The reactor will be regulated to provide constant steam pressure in the boiler regardless of the load on the turbo-generator. This avoids the use of a main line pressure reducing valve, which would otherwise be necessary if the reactor were controlled for contant reactor temperature. The reactor will also be designed so that load may be increased from 15 per cent to 100 per cent load over the period of half an hour and so that the load may be taken off the unit at the same rate. Operation below 15 per cent of full load is not contemplated because of reactor limitations. If the turbo-generator trips out or is taken out of service for minor reasons and the expectation is that the unit will be restored in a few hours, the reactor will be kept in operating condition and loaded to 15 per cent of capacity by means of a steam by-pass around the main turbo-generator. By means of a pressure reducing valve and desuperheater in the by-pass, steam will be passed directly to the condenser and the heat rejected to the river.

The nuclear steam generator comprises chiefly the reactor, the necessary piping and valves, the boilers, the circulating pumps, the pressurising system, coolant treatment and make-up systems, the fuel element charging and discharging equipment, the shielding, the reactor controls and associated instrumentation, and the safety containment vessels. Its maximum design rating is 500MW of heat and the steam produced is saturated at 405 lb per square inch gauge. The reactor is an internal thorium thermal converter. It is fuelled initially with highly enriched U-235 and is moderated and cooled with pressurised light water. The active portion of the reactor is a right cylinder about 6ft in height and about 6ft in mean diameter. The core is made up of over 100 fuel elements, each of which is square in cross-section and contains alternate fuel and fertile plates separated by coolant channels. The fuel plates consist of uranium-Zircaloy core clad with Zircaloy, and the fertile plates consist of thorium core clad with Zircaloy. Thorium was chosen as the fertile material on the basis of its structural properties, its compatibility with Zircaloy, its low irradiation damage, and its superior ability to supplement the original fuel supply. With the passage of time an appreciable portion of U-233 produced in the thorium is consumed *in situ* and the remainder contributes to the reactivity of the core in a favourable way. The core is surrounded laterally by a 6in water reflector and the entire assembly is housed in a thick-walled pressure vessel. Steel thermal shields protect the pressure vessel against structural damage and excessive heating from neutron and gamma flux. A portion of the main coolant flow is diverted to cool the thermal shields and pressure vessel.

With about 55 per cent of the core volume filled with water and an inventory of about 8275 kg of thorium, approximately 275 kg of fully enriched U-235 provide sufficient excess fuel to accommodate the various reactivity changes. Under normal conditions 120,000 gallons per minute of coolant water are passed through the reactor. The flow is upward from four inlet connections in the lower section of the pressure vessel to four outlet connections in the upper section of the vessel. The pressure is maintained at 1500 lb per square inch absolute and the coolant temperature is limited by a maximum fuel plate surface temperature of 600 deg. Fah. The mean reactor water outlet temperature is 510 deg. Fah, and the mean reactor water inlet temperature is 480 deg. Fah. The average heat flux for full power operation of a new core is about 169,000 B.Th.U. per hour per square foot. This is reduced somewhat as the production of heat is spread to the thorium plates, and since no more than one third of the core will be replaced at any time, will probably never exceed the initial value. For the proper operation of this reactor, an excess of reactivity over the cold, clean core is required in order to compensate for the effects of : (1) increase in moderator temperature, (2) build-up of fission product poisons, (3) burn-out of fuel and build-up of higher isotopes, and (4) short-time shut-down build-up of Xe-135. This excess reactivity is balanced as required by twenty-one individually driven cross-shaped boron steel control rods. The effective part of each rod is about 5ft 6in.

The reactor pressure vessel is a cylindrical shell of carbon steel about 10ft in diameter and about 30ft high. The inner face of the vessel will be clad with 18-8 stainless steel. The vessel is set vertically in a containment shell. A skirt support permits the temperature expansion of the vessel while holding it firmly in position. The vessel will be designed and fabricated in accordance with the A.S.M.E. Power Boiler Code for a design pressure of 1800 lb per square inch absolute and a temperature of 550 deg. Fah. The containment shell will be filled with demineralised water to a depth of 18ft above the closure head of the vessel. This water will provide shielding during normal operation of the reactor and will also protect manipulator personnel during fuel loading and unloading stages. The primary coolant system consists of four loops in parallel. The reactor is situated at the low point in the system. This permits the drainage of a boiler loop without uncovering the core and facilitates the natural convection removal of decay heat in the event of pump failure. Each boiler consists of two major components : an evaporator section and a separate steam drum. The evaporator section consists of U-shaped, 18-8 stainless steel tubes, the ends of which are welded into heavy tube sheets, enclosed in a U-shaped carbon steel shell. With feedwater at 332 deg. Fah., each of the four boilers will generate about 472,000 lb of saturated steam per hour at a pressure of 405 lb per square inch gauge under full power conditions. During shutdown heat will continue to be generated in the fuel elements of the reactor by radioactive decay of the irradiated material. The normal shutdown procedures are such that the elements are cooled by forced circulation until they are able to be cooled by natural convection. In the event of power failure, emergency drives for one main cooling pump in each loop will supply adequate circulation during the shutdown period.

The fuel elements are assemblies of 0·060in thick fuel plates and 0·080in thick fertile plates spaced alternately to provide 0·100in water channels. The individual plates are about 2½in wide and are assembled in two rows in order to provide a square cross-section with a lateral dimension somewhat more than two plate widths. The exact dimensions and total number of assemblies depend upon the final specifications for the control rod positions. All assemblies are of identical dimensions to obtain flexibility in the fuel loading programme. There will be a handling system inside the station for removing spent fuel elements and installing fresh elements. This handling system will also transfer spent fuel from temporary storage inside the station to shipping coffins for transport to off-site processing facilities. All of these operations must be carried out remotely. Each element will be shipped to and stored at the site in a hermetically sealed metal container. A fuel element storage vault is situated above the reactor shield tank adjacent to a multi-purpose handling device. The multi-purpose handling device serves as a working platform for indexing the special tools over desired refuelling locations within the shield tank and provides a partial closure of the shield tank for the control of shield tank ventilation while the fuel handling operations are under way. A steel-lined concrete pit, for spent fuel storage, is situated next to the reactor shield tank. The spent fuel elements are transferred to the storage under water through a transfer canal.

Fig. 17 (page 1000) shows the full-scale experimental version of the core of the Consolidated Edison reactor being assembled for an initial series of tests involving controlled fission chain reactions at the Babcock and Wilcox critical experiment laboratory, Lynchburg, Virginia. The proposed cores for the Consolidated Edison reactor will be studied in this critical experiment.

Westinghouse Electric Corporation

The Westinghouse Electric Corporation, of Pittsburgh, Pennsylvannia, is another American firm now constructing its own pile for development. The Westinghouse Testing Reactor is designed to operate at a thermal power level of 20MW with a peak thermal neutron flux of 8×10^{13} neutrons per square centimetre per second. It is intended to be used for developing power reactor fuel elements, radiation damage testing of electrical materials and components, and the limited production of radioactive isotopes. The reactor is being constructed on a 750-acre site in Sewickley, Pennsylvania, twenty-nine miles south east of Pittsburgh.

The reactor core will be contained in a stainless steel pressure vessel with an inside diameter of 8ft and an overall height of about 33ft. The core may consist of from 51 to 122 cylindrical fuel elements, 50in long and 2½in in diameter, each containing about 200 grammes of uranium enriched to 90 per cent in the isotope U-235. The fuel in each element will be contained in three concentric fuel bearing cylinders, each of which is about 36in long. The fuel loading in the core may vary from 12 kg to 25 kg of U-235. The loading will be adjusted to provide an excess reactivity of 9 per cent above that required for criticality without experiments loaded in the reactor. This excess reactivity will be required to (1) override the neutron absorption of the xenon present in the reactor under equilibrium conditions ; (2) to overcome the decrease in reactivity which results from the temperature rise which takes place when the reactor is operating ; and (3) to replace the reactivity lost as the U-235 burns out during the planned operating cycle of one month. Demineralised natural water will be used for the coolant, moderator and reflector. There will be nine control rods in the reactor, each having a control value of approximately 3½ per cent excess reactivity. Each rod will consist of an aluminium-clad cadmium cylinder attached to the top of a standard fuel element section. The rods will be arranged in two concentric rings—an inner ring with three rods and an outer ring of six rods. The rods will be attached to the driving mechanism by scram magnets. In the case of a scram, the rods will be driven into the core by gravity and the pressure due to the downward coolant flow. The reactor will be scrammed as a result of a decrease in the excitation current of the magnets holding the rods. An electric power failure, therefore, will shut down the reactor. The rods consist of poison and fuel sections. In the event of a scram the fuel bearing portion of the control rods drop out of the core as the poison section replaces it.

A primary coolant flow of 13,660 gallons per minute of demineralised natural water will be intiated from a 60,000-gallon elevated storage tank. The coolant enters the top of the reactor tank and is split into two streams. One stream of 9107 gallons per minute cools the reactor core and the other stream passes through the reflector region and cools the non-pressurised experiments. The two streams join at the bottom of the reactor and the coolant flows upward through the thermal shields and out of the reactor. The effluent water from the reactor flows into a 30,000-gallon surge tank, which would provide emergency cooling in the event of the primary pumps failing. Water from the surge tank passes through two coolant pumps, two water-to-water heat exchangers and then to the elevated storage tank. During normal operating conditions the bulk inlet water temperature is expected to be 115 deg. Fah. and the bulk exit temperature 125 deg. Fah. The corresponding average core temperature is 130 deg. Fah. The experimental facilities to be contained in the reactor include the following :—

(*a*) One 6in O.D. high-pressure test thimble situated in the centre of the reactor designed to operate at a maximum of 600 deg. Fah. and 2000 lb per square inch ;

(*b*) Six 3in O.D. high-pressure test thimbles similar to (1) above situated symmetrically in the reactor core ;

(*c*) Sixty non-pressurised thimbles around the periphery of the active portion of the core ;

(*d*) Provisions for five experimental rabbit facilities around the rim of the core ; and

(*e*) An 8in I.D. beam hole.

To prevent the release of fission products to the environs in the event of a reactor incident, the reactor is to be housed in a cylindrical steel containment vessel approximately 70ft in diameter and 67ft high. The nuclear characteristics of the proposed Westinghouse Testing Reactor are similar in many respects to the A.E.C. Materials Testing Reactor (MTR) operating at the National Reactor Testing Station in Idaho.

Personal and Business

Appointments

MR. G. W. HALL, F.R.Ae.S., has been appointed chairman of the Fairey Aviation Company, Ltd.

MR. C. E. ROPER has been appointed manager of the aviation division of Elliott Brothers (London), Ltd.

MARTONAIR, Ltd., has announced the appointment of Mr. V. Chidgey as technical representative for Wales.

SIR NEVIL MACREADY, Bt., has been appointed manager of the supply department of Mobil Oil Company, Ltd.

BABCOCK AND WILCOX, Ltd., has announced that Mr. Iain Maxwell Stewart, A.M.I.Mech.E., and Lord Bridges have been appointed directors.

LLOYD'S REGISTER OF SHIPPING has announced that Mr. James Turnbull has been promoted to the rank of deputy chief ship surveyor with effect from July 1.

MR. R. A. BARTLEY, A.I.Mar.E., has been appointed technical sales representative for the north-eastern area for Sir W. H. Bailey and Co., Ltd.

FRED MYERS, Ltd., has announced the appointment of Mr. A. F. Stevenson as sales manager of its division dealing with fork lift trucks and materials handling equipment.

THE SOCIETY OF CHEMICAL INDUSTRY has announced that Mr. W. E. Dick has been appointed editor of *Chemistry and Industry*, in succession to Mrs. Bush, who is to retire at the end of June.

THE EXPORT CREDITS GUARANTEE DEPARTMENT has announced that the president of the Board of Trade has appointed Mr. W. J. P. Webber to the department's advisory council in succession to Mr. H. Douglass.

VICKERS-ARMSTRONGS (AIRCRAFT), Ltd., has announced that Mr. H. H. Gardner, F.R.Ae.S., Mr. A. W. E. Houghton, Mr. B. Stephenson, F.R.Ae.S., and Mr. S. P. Woodley, have been appointed directors.

THE MINISTRY OF SUPPLY states that Mr. R. P. Probert has been promoted to deputy chief scientific officer and appointed deputy director, engine test facilities, National Gas Turbine Establishment, Pyestock, Farnborough.

THE BRITISH TRANSPORT COMMISSION has announced that Mr. B. X. Jessop has been appointed assistant traffic adviser (passenger) at the Commission's headquarters in London. Mr. S. B. Yentis has been appointed works study assistant.

ALFRED HERBERT, Ltd., announces the following appointments on its board of directors: Mr. D. M. Gimson, chairman, Colonel C. W. Clark, deputy chairman and joint managing director, and Mr. J. C. Blair, joint managing director.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION has announced the appointment of Captain T. H. Farnsworth as a member of the Air Registration Board in place of Captain A. M. A. Majendie, whose term of service as pilot representative expires on June 30.

MR. WILLIAM LEWIS LITLE has been appointed chairman of Ruston-Bucyrus, Ltd., in succession to Mr. William Wheeler Coleman. Mr. Coleman remains a director and has been elected honorary chairman of the company. Mr. William Savage has retired from the board of directors.

THE MINISTRY OF EDUCATION has announced that Sir Harold West is resigning his appointment as chairman of the governing body of Loughborough College of Technology at the end of the present college academic year. Sir Edward Herbert has accepted the Minister's invitation to become chairman as from September 1.

Business Announcements

WATES, Ltd., states that it has opened a regional office at Exchange Buildings, New Street, Birmingham, 2

DUCTILE STEELS, Ltd., states that it has formed a separate company, Ductile Sheet Stockists, Ltd., to deal with the sheet side of its business.

BASTIAN AND ALLEN, Ltd., states that it has opened a branch office at Cabinet Chambers, 20a, Basinghall Street, Leeds, 1 (telephone, Leeds 31881).

UNITED DOMINIONS TRUST, Ltd., has announced the opening of a branch office at 15, Market Hill, Cambridge (telephone, Cambridge 59774).

NORRIS WARMING COMPANY, Ltd., and F. A. NORRIS AND CO., Ltd., state that they have opened new offices at 38–40, Elm Grove, Portsmouth.

ROLL RACE CONVEYORS, Ltd., states that it has moved from Marylebone Lane to 13–16, Jacob's Well Mews, George Street, London, W.1 (telephone, Hunter 0898).

PEGLER AND LOUDEN, Ltd., states that it will open a branch at 87–91, Shaw Street, Liverpool, 6, on Monday, July 15. Mr. Normand Michell has been appointed branch manager.

COURTAULDS, Ltd., states that, with effect from July 1, the address of its public relations department will be 16, St. Martin's-le-Grand, London, E.C.1 (telephone, Monarch 8811).

SIR W. H. BAILEY AND CO., Ltd., states that its London offices and sales depot have been moved from 4, Domingo Street, E.C.1, to Selinas Lane, off Whalebone Lane South, Dagenham, Essex (telephone, Dominion 2277/8/9).

QVF, Ltd., has announced that Mr. B. H. Turpin, managing director, has left England on a transatlantic tour. Mr. J. G. Window, sales director, is visiting Norway, Sweden, Finland, Denmark, Holland, Italy, and France.

FULLER ELECTRIC, Ltd., states that the name of Asea Electric, Ltd., has been changed to Fuller Electric, Ltd., and the name of Fuller Electrical and Manufacturing Company, Ltd., has been changed to Asea Electric, Ltd., and that the business formerly carried on by those two companies will in future be carried on by Fuller Electric, Ltd.

THE INSTANT STARTER ENGINEERING COMPANY, Mitre House, 177, Regent Street, London, W.1, has been registered as a public company. Its board of directors is constituted as follows: Mr. A. J. Whitehead, chairman, Mr. L. E. Witney, Mr. John Buchan, Mr. Alan Hess, and Mr. James Murray. The secretary is Mr. R. A. Sprackland.

CHARLES J. LOMAX AND SON have announced that they have moved to 68, Barton Chambers, Barton Arcade, Deansgate, Manchester, 3 (telephone, Blackfriars 8534), and that they have taken over the offices of Messrs. T. B. Farrington and Son, of Llandudno. The address of this branch office is 18, Trinity Square, Llandudno, North Wales (telephone, Llandudno 6143).

THE TAYLOR WOODROW GROUP has announced that Mr. Frank Taylor has relinquished the chairmanship of Taylor Woodrow Construction Ltd. Mr. A. J. Hill, managing director, has been appointed to succeed him as chairman, and Mr. T. Freakley and Mr. T. Reeves have been appointed joint deputy managing directors, Mr. D. A. J. Ballinger, Mr. B. F. Higgs, and Mr. H. R. Macdonald have been appointed directors. A new company, Taylor Woodrow (Overseas), Ltd., has been formed under the chairmanship of Mr. Frank Taylor; Mr. J. Hanson, Mr. A. J. Hill and Mr. L. Olorenshaw have been appointed joint deputy managing directors. Negotiations have been completed, it is stated, to purchase control in the British Overseas Engineering Construction Corporation, Mr. E. J. Woolf has been appointed chairman and Mr. P. L. Baker, a director. Mr. R. A. Wykes has been appointed a director of Taylor Woodrow (Nigeria), Ltd. Mr. G. W. Raybould, home sales manager of Taylor Woodrow (Building Exports), Ltd., has been appointed a director.

Contracts

SOLUS-SCHALL, Ltd., 15–18, Clipstone Street, London, W.1, has received a contract from Taylor Woodrow, Ltd., to carry out gamma radiography on a 10in pipeline from Port Hardcourt, in Nigeria, to Oloibiri, near Kuglo, 60 miles away. A new oil strike has been made there, and the line is being constructed for Shell Petroleum (Nigeria), Ltd.

SIMON-CARVES, Ltd., Cheadle Heath, Stockport, has received from Australian Iron and Steel (subsidiary of the Broken Hill Proprietary Company, Ltd.) a contract for a complete coke oven battery and by-product plant at the Port Kembla steel works. The battery will comprise ninety-six twin-flue compound underjet ovens in two blocks of forty-eight ovens each, and will carbonise about 1,000,000 tons of coal a year.

HENRY BALFOUR AND CO., Ltd., Leven, Fife, has received an order from the West Midlands Gas Board for a tower box purifier, to be installed at the Worcester Gas Works. Initially the plant will have a total oxide capacity of 28,400 cubic feet, and the gas throughput will be 4,000,000 cubic feet per day. Eventually it is hoped to double this throughput by adding six further oxide-holding trays to the east tower. The installation is scheduled to be completed by the end of 1958.

FERRANTI, Ltd., has received an order for transformers worth nearly a million dollars from the Tennessee Valley Authority, U.S.A. The order covers eight single-phase transformers at a total cost of 994,920 dollars. Six will be used to form two three-phase banks and the remaining two will be used as spares units. The transformers are of 33,333kVA, 154kV.

WOODALL-DUCKHAM CONSTRUCTION COMPANY, Ltd., 63–77, Brompton Road, London, S.W.3, has received an order to extend the coking plant at the Redbourn Works, Scunthorpe, of Richard Thomas and Baldwins, Ltd. This order, which is valued at over £1,500,000, includes two further batteries totalling sixty-two coke ovens with a daily coal carbonising capacity of some 1300 tons, by-product recovery plant and coal and coke-handling plants.

HEAD WRIGHTSON PROCESSES, Ltd., has been awarded a contract by the Danish Atomic Energy Commission for the design, engineering, procurement and erection supervision of a materials testing reactor similar to those it is now building for the U.K.A.E.A. at Harwell and Dounreay. It is planned that the reactor will be completed before the end of 1959. These reactors have the name "Pluto" and their counterpart, "Dido," the most powerful experimental reactor in Western Europe, has now been in operation at Harwell for over six months. "Pluto," like "Dido," is an enriched-uranium heavy-water-moderated reactor with a flux of 10^{14} neutrons per square centimetre per second at a thermal output of 10MW. The Danish "Pluto" reactor will enable essential research to be conducted on the testing of materials under the effects of irradiation. The reactor will be built at the Danish Atomic Research Centre. The contract has the approval of the U.K.A.E.A., who will supply the necessary enriched fuel elements.

Miscellanea

CIVIL AND MILITARY DEVELOPMENT.—It has been disclosed that the civil version of the Rolls-Royce "Conway," the R. Co. 10, has a take-off thrust of 16,500 lb; the engine is 11ft long and 3ft 6in in diameter. Boeing 707, Douglas D.C.8 and Vickers V.C. 10 airliners have been ordered with the by-pass engine installed. Four "Conway" R. Co. 11 engines will be used in the Handley Page "Victor" B.2.

METAL MARKING.—We are informed that the firm of A. Levermore and Co., Ltd., 110, Cannon Street, London, E.C.4, has been appointed distributing agents in this country for "Markal Paintstiks," which are manufactured by the Markal Company of Chicago. These "Paintstiks" are made in a number of types for the marking of all classes of metal in the icy, greasy, rough or smooth condition, and through a range of temperatures from below 50 deg. to 2400 deg. Fah.

ABRASIVE CLOTH AND PAPER PLANT.—An extension to the works of the English Abrasives Corporation in March Lane, London, N.17, has been equipped with a new plant for the manufacture, by a continuous process, of waterproof, resin-bond, abrasive cloths and papers. In this process a layer of adhesive is first applied to the continuous roll of cloth or paper and on to this layer a controlled thickness of abrasive is placed by an electrostatic deposition process which is stated to ensure exact spacing of the grains in a vertical position on the adhesive. After a preliminary curing process a top coat of adhesive is applied to bind the abrasive grains in place before final curing is effected at high temperature.

METAL SHELVING.—A new shelving system, introduced by Savage and Parsons, Ltd., Watford, Herts, is designed to enable shelving to be easily erected in almost any position for either permanent or temporary use. The system uses removable cantilever shelf brackets of pressed steel which are supported by hook ends in slots on a fitted vertical upright which is screwed to a wall or on a double-sided upright fixed to floor and ceiling. The components are supplied stove-enamelled in alternative colours or they can be nickel or chrome-plated or zinc sprayed and galvanised. The range of components available include standard right-angle brackets, from 5in to 18½in long; slanting brackets, for display purposes, reading desks, &c., which make an angle of 110 deg. with the upright; book-end supports which can be used also for subdividing shelves; plates for joining shelves into continuous lengths, and special units for use where shelving is required to be detachable from the bracket. A high degree of flexibility in shelf layout is possible, as the position of the shelves can be altered by simply moving the brackets up or down. The wall supports for the shelves are supplied in twelve standard lengths of from 4½in to 94½in, but special sizes are also available.

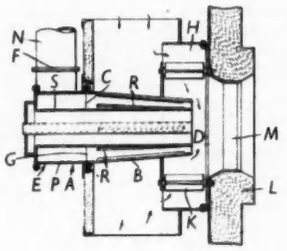
British Patent Specifications

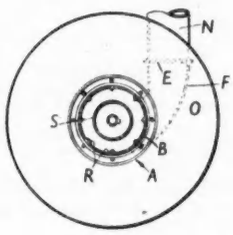
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

BURNERS AND SPRAYERS

775,730. July 6, 1955.—Pulverised Fuel Burners, Foster Wheeler, Ltd., Foster Wheeler House, 3, Ixworth Place, London, S.W.3.

Referring to the drawing, the fuel burner *A* for pulverised fuel comprises a main body *B*, with an inlet *C* and an outlet *D*, and a volute inlet section *E* with an inlet *F* and an outlet *G*. The body consists of a frusto-conical-shaped casing which tapers gradually from its inlet *C* to its outlet *D*. The inlet *C* communicates with the outlet *G* of the volute section *E*, while the outlet *D* communicates with a windbox *H* of an air supply. Dampers *K* in the windbox, control the air supply to the burner. The air supply means is attached to a furnace wall *L* adjacent to the burner





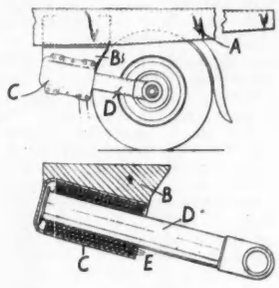
No. 775,730

opening *M*. In operation, when a mixture of pulverised coal and air is supplied to the burner volute section *E* by the conduit *N*, the mixture enters the inlet *F* and impinges against the scroll *O*, where a tangential or circumferential velocity is imparted to the mixture due to its change of direction. As the mixture leaves the scroll the coal particles are thrown to the outside of the coal-air mixture against the inner surface of the cylindrical portion *P* by centrifugal force, and separate from the air stream. Thereafter the particles move along the inner portion *P* and the body *B* towards the outlet *D*, while part of the separated air stream moves centrally of the portion *P* and the body *B* towards the outlet *D*. The separated coal dust travelling along the portion *P* and the body *B* moves into this high-velocity area, and is transported in the high-velocity carrier stream, thereby forming a spiral rope of coal dust. When this spiral rope passes in front of the body inlet *C* towards the outlet *D* the spiral rope impinges against the bars *R*, which are substantially at right angles to its flow path, and is dispersed or broken up. After dispersement, the carrier stream tends to re-form and to form another coal-air rope before this can be formed the stream again impinges on another bar *R* and passes as a coal and air stream out of the body through the outlet *D*. Thus the bars *R* prevent a coal-air rope forming in the body *B* and a uniform mixture of coal and air is discharged around the periphery of the outlet *D* for proper comingling with the air to support combustion. The sleeve *S* prevents the coal-air mixture passing through the outlet *D* from recirculating back through the outlet to fill the low-pressure area or void extending along the axis of the burner. Optimum results are obtained when the opposite ends of the bars *R* are spaced somewhat from the inlet and outlet of the body as shown in the drawing.—*May* 29, 1957.

ROAD TRANSPORT

776,620. January 5, 1955.—Suspension Means for Vehicle Axles, Cranes (Dereham), Ltd., South Green Works, Dereham, Norfolk. (*Inventor : William David Chaplin.*)

Referring to the drawing, on each side of the chassis *A* there is supported by brackets *B* a semi cylindrical housing *C*, the axis of which is inclined downwardly and rearwardly parallel to the length of the vehicle. Extending coaxially into the casing is the end of a radius arm *D* of circular section having



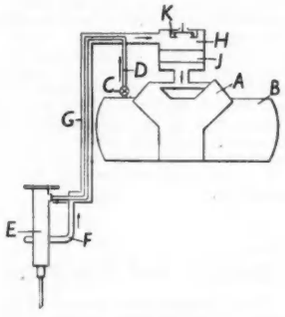
No. 776,620

a flanged end. The other end of this radius arm is connected to the axle. Surrounding the end of the radius arm *G* within the housing are a number of rubber bushes *E* which are compressed by the cover. Between successive bushes are steel semi-cylindrical separators. As shown in the lower view, under no load conditions, the radius arm lies coaxial with the housing. When load is applied, the radius arm is displaced relative to the axis of the casing compressing the rubber bushes. The amount of deflection will vary according to the assembly and either one, two, three or more laminations may be used to achieve this end. Modified designs are also shown in the specification.—*June* 12, 1957.

WORKSHOP TOOLS AND APPLIANCES

776,884. November 8, 1954.—Silencer for Pneumatic Drills, Vokes, Ltd., Henley Park, Guildford, Surrey. (*Inventor : Cecil Gordon Vokes.*)

According to the invention the exhaust from a pneumatic drill is connected through a conduit including an expansion chamber back to the inlet of the compressor. The conduit must, of course, be of greater capacity than the pressure inlet hose to the drill to accommodate the expansion of the air occurring in the drill motor. In the drawing, a com-



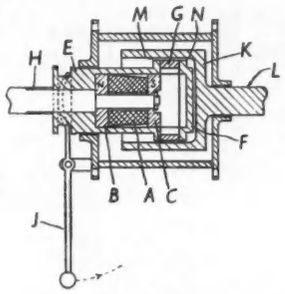
No. 776,884

pressor *A* is connected to a pressure receiver *B*, from which a valve *C* controls the outlet of air to a flexible hose *D*. The flexible hose is led to the inlet of the air motor of a pneumatic drill *E*, the exhaust from which is carried through a branch pipe *F* to flexible hose *G* largely concentric with the hose *D*. The hose *G* is connected to an expansion chamber *H* fitted to the compressor air inlet. A filter *J* spans the expansion chamber. A non-return valve *K* in the top wall of the expansion chamber is normally maintained closed by pressure within the chamber, but, should the pressure in the chamber fall to less than atmospheric pressure, the valve *K* will open to admit air. Quite apart from the silencing effect the arrangement should result in saving in the power expended at the compressor, since the exhaust from a drill is very considerably above atmospheric pressure, yet expansion within the drill motor cools it considerably so that a greater weight of air should be inspired at each stroke. The exhausts from a number of drills may be connected to a single expansion chamber.—*June* 12, 1957.

ELECTRICAL ENGINEERING

776,714. July 27, 1954.—Magnetic Coupling Devices for Brakes and Clutches, Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4. (*Inventor: James William Walley.*)

The object of the invention is to provide a magnetic coupling device in which the magnetic field is produced by permanent magnet means and can be controlled to vary the extent of coupling provided. Referring to the drawing, a permanent magnet *A*, with mild steel end plates *B* and *C*, is fastened coaxially to the driving shaft. The magnet is surrounded by a composite cylinder comprising parts *E* and *F* of magnetic material such as mild steel, separated by a non-magnetic section *G* of brass for example. The cylinder rotates with the driving shaft, but is slidable axially with respect to the shaft along grooves *H*, a lever *J* being incorporated to provide control of this movement. A cup-shaped part *K* on the end of the driven shaft *L* surrounds the composite cylinder leaving small gaps *M* and *N* between the part

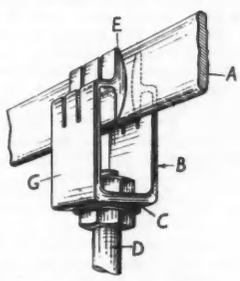


No. 776,714

K and the cylinder parts *E* and *F*. When the cylinder is in the minimum coupling position shown, the poles of the magnet *A* are bridged by the local magnetic circuit provided by the left-hand magnetic portion *E* which carries all the flux from the magnet. When, however, the cylinder is moved to the extreme left, the section *G* is inserted between the magnet poles, and the magnetic flux is re-routed along the "easiest" magnetic path between the magnet poles, namely, from the N pole via the part *E*, the gap *M*, the mild steel part *K*, the gap *N* and the part *F* back to the S pole, thereby providing maximum coupling between the driving and driven shafts. As will be apparent the parts *E* and *F* act as pole pieces for the magnet in this extreme left-hand position of the composite cylinder. The basic coupling device illustrated may obviously be arranged to operate by the setting up of a hysteresis effect or an eddy current effect or a combination of both such effects.—*June* 12, 1957.

776,872. June 28, 1954.—Electric Contact Members, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventor : Frank Hugh Morris.*)

Referring to the drawing, the electric contact member is arranged to co-operate with the busbar in the form of a flat contact blade *A*. The member comprises an open metal loop *B* generally of U form, the base *C* of the loop being flat and is secured by a bolt *D* to an electric terminal. The contact member



No. 776,872

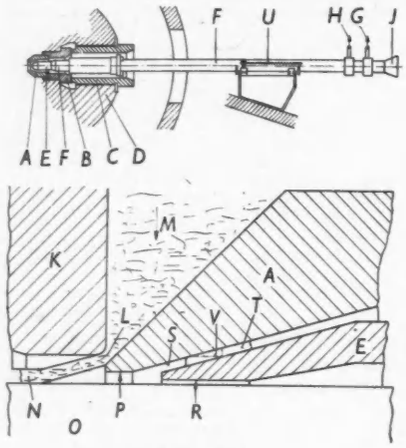
thus forms part of a plug-in device adapted to connect with the flat busbar *A*. The limbs *G* at their free ends are turned inwardly and each limb of the loop is formed in one with a contact portion which is in the form of a plate *E* which has a convex contact surface. Each contact plate forms as it were a cross-arm to a T-shaped portion at the ends of the metal loop and they are biased towards one another by the limbs of the loop, this biasing force being applied directly behind each contact plate and in a direction generally perpendicular to the plane of the blade *A*. When the blade *A* lies between the plates *J*, it is firmly gripped by them and good electrical contact is assured. In the contact member shown in the drawing, each plate and part of its support—that is, a part of the loop—

is divided into sections by slitting in one or more planes perpendicular to the plane of the plate. In this way, each plate is formed by a number of contact fingers. One particular advantage of the construction described is the relatively low cost of producing extruded bar and forming a number of contact members by cutting the bar into sections of the right length. The contact member may be made by a continuous casting process which has the advantage that, unlike a contact made by an extrusion process, the grain of the metal would not all be one way.—*June* 12, 1957.

MACHINE TOOLS

776,570. February 7, 1955.—PRESSES FOR SHEATHING CABLES, The Schloemann Aktiengesellschaft, Steinstrasse 13, Düsseldorf, Germany.

The invention relates to an extrusion press for sheathing cables with metal, having a hollow mandrel into which is pushed the front end of a tube surrounding the cable which is passing through the press and which is being protected against heat by the tube.



No. 776,570

As will be seen from the drawing, the mandrel *A* is inserted into the mandrel holder *B*, which, in its turn, is held by a bush *C* screwed into the press body *D*. The front end *E* of the protective tube *F* is pushed into the mandrel. The protective tube is designed as a cooling pipe. The cooling water runs into the pipe at its rear end at *G* and leaves the pipe at *H*. The cable which is to be sheathed is inserted at *J* and leaves the protective tube at its front end *E*. As shown in the lower view, the point of the mandrel faces a die *K*. Between these parts a sheath-forming gap *L* is provided. The metal which is to be extruded and which is fed in the direction of the arrow *M* forms the sheath *N* round the cable *O*. As shown, the bore *P* of the point of the mandrel *A* is a little larger than the bore *R* of the front end *E* of the protective tube, so that the cable, even if it makes contact with the front end of the tube, just avoids touching the internal surface of the point of the mandrel, which may be heated to a high temperature. The bore of the point of the mandrel is tapered at *S*, and may have a vertex angle of 30 deg., so that the generator *S* in the section makes an angle of 15 deg. with the cable axis. The front end *E* of the tube *F* is also tapered and is provided with four stops *T*, which keep the mandrel and the tube concentric with one another by bearing against the internally conical surface *S*. Springs *U* apply a longitudinal pressure to the protective tube and tend to push it constantly forward, as shown in the upper view. The accurate concentric position of the tube in the mandrel can also be achieved by ensuring that the tapered end of the protective tube makes contact with stops *V*, which are provided on the internal surface of the bore of the mandrel. Since the diameter of the frusto-conical surfaces is liable to vary with changes of temperature, slight axial movements of the protective tube may be necessary in order to maintain contact between the mandrel and the tube through the abutments *T* or *V*. The springs *U* constantly urge the tube towards and into the mandrel, thereby maintaining contact if the mandrel expands. In the event of the mandrel contracting, however, since the above-mentioned angle of 15 deg. is greater than the angle of friction between the frusto-conical surface and the abutments *T* or *V*, the tube *F* will be pushed back, towards the right of the drawing, against the thrust of the springs, thereby maintaining contact, and keeping the tube and the mandrel co-axial with one another, while obviating any inadmissible pressure of the mandrel upon the tube.—*June* 12, 1957.

Technical Reports

Life Testing of Impregnated Paper Capacitors : Variability of Results (Ref. L/T336). By H. F. Church. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 4d.—It is shown by a statistical analysis of a large amount of existing data that the observed wide variability of d.c. life test results on impregnated paper capacitors can be explained in terms of the geometry of the dielectric. The statistical distribution of short-time d.c. breakdown stress and of life under normal stress conditions are related to the same geometrical considerations and the practical implications of this are discussed. The effects of capacitor size on life and variability are also considered.

Wind Data Related to the Generation of Electricity by Wind Power (Ref. C/T115). By J. R. Tagg, B.Sc. (Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 30s., postage 7d.—This report describes the results obtained (up to the end of 1954) from a wind survey of Great Britain and Ireland. Its purpose was to assess the potentialities of the wind as a source of electrical energy. Initially, the survey covered the western and south-western coastlines, but later, to complete the study of winds over the whole country, several sites on the East Coast were included. The results of these measurements are analysed and presented in both tabular and graphical form. A section dealing with the results of wind measurements in other countries is included to help in assessing the potentialities of wind power overseas and to compare different wind régimes.

Oscillographic Observation of Short Duration Arcs Between Separating Platinum and Palladium Contacts (Ref. U/T135). By J. Riddlestone, B.A. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 12s. 6d., postage 4d.—Preliminary records of arc voltages of very short duration between separating contacts have been obtained with the E.R.A. ultra-high-speed oscillograph. The contacts were operated under the same conditions as those used for the transfer measurements described in Reports Ref. U/T130 and U/T133. The closed circuit currents were 4·5A and 8A for platinum and 4·5A for palladium contacts, the supply voltage was 6V and the effective inductances ranged from the minimum (<0·1 μH) to 4·7 μH.

The limitations of the method of obtaining the records are discussed and the need for development of more efficient methods is stressed. There is insufficient evidence from the records on which to base a theory of the arc at separation or a relationship between transfer and characteristics. Representative records are shown and an analysis is given of the more important characteristics of the arc voltages and durations. These records show that low-voltage short-duration arcs exist between separating platinum and palladium contacts under all the conditions used for these tests. The durations of the arc are approximately proportional to the closed-circuit current and the circuit inductance. The voltages are low ; the minimum value is about 7V and the maximum is not generally more than twice this value. From approximate measurements of extinction currents in the arc it is considered that the low values which sometimes occur may be due to "activation" of the contacts by grease. Some reference is made to activation and the possible effect on transfer.

Catalogues and Brochures

BX PLASTICS, Ltd., Higham Station Avenue, London, E.4.—Leaflet describing Bextrene toughened polystyrene sheet.

GIBBONS BROTHERS, Ltd., P.O. Box 19, Dibdale, Dudley, Worcs.—Leaflet illustrating reverberatory melting furnaces.

GATE ELECTRONICS, Ltd., Tudor Grove, London, E.9.—Leaflet No. 176, describing the T.C.B. series transistor machine controllers, batch counters.

THE HYMATIC ENGINEERING COMPANY, Ltd., Redditch, Worcestershire.—Leaflet describing the Hymatic-Hydrovane all-purpose mobile compressor, type 7P100.

TUBE INVESTMENTS, Ltd., The Adelphi, London, W.C.2.—Booklet entitled "This is T.I. To-day," which lists the firm's companies and the products they manufacture.

THE PALNUT COMPANY, Ltd., Palnut Works, 28, Elder Row, Brighton, 1.—Leaflet illustrating and describing "Palnut" safety lock washers. These washers are especially suitable for railway plant and equipment subject to vibration.

MIRRLEES, BICKERTON AND DAY, Ltd., Hazel Grove, Stockport, Cheshire.—Two catalogues : No. 5076 illustrates and describes the Mirrlees range of JL diesel engines ; and No. 5074 illustrates and describes the Mirrlees range of KV diesel engines.

ALBRIGHT AND WILSON (MFG.), Ltd., 1, Knightsbridge Green, London, S.W.1.—Leaflet describing "Kanigen" plate, a hard and corrosion-resistant metallic coating, which can be applied to most metals, glass, ceramics and thermosetting resins.

HIGH DUTY ALLOYS, Ltd., Slough, Bucks.—Technical data booklet for "Magnuminium" and magnesium, zirconium and thorium containing alloys. The physical and specified mechanical properties of the alloys manufactured by this firm are also given.

ALMHULTS BRUK AKTIEBOLAG, Almhult, Sweden.—Leaflet giving details and specification of a new automatic gear hobbing machine introduced by this firm. The sole agent in this country is the Mortimer Engineering Company, 210, Acton Lane, Harlesden, London, N.W.10.

G. AND J. WEIR, Ltd., Cathcart, Glasgow, S.4.—Pamphlet No. 167, entitled "Weir Low-Pressure Evaporating and Distilling Plant." It shows a diagrammatic arrangement of the plant and gives some details of this plant. Also a leaflet about electrically driven three-throw high-pressure reciprocating pumps.

GENERAL REFRACTORIES, Ltd., Genefax House, Sheffield, 10.—Brochure entitled "'GR' Refractories for All Industrial Purposes." An endeavour has been made to include in this brochure every kind of refractory material produced and manufactured by this company. Also a leaflet entitled "'Durax' Plastic Refractories," giving information about plastic firebrick composition, castable concrete, plastering cement, jointing cement, gunning or plastering cement, element cement, and about the physical properties of "Durax" plastic refractories.

THE ENGLISH ELECTRIC COMPANY, Ltd., Stafford.—Publications : No. SG/338, "An Outline of Electrical Distribution Systems," describing the general problems which usually decide the kind of scheme to be used and giving a number of typical systems which can be used as a basis for most individual requirements ; and No. SG/339, "Protective Devices Applied to Electrical Switchgear," reviewing the more general kinds of electrical protective schemes for systems up to 11kV, 250MVA, and giving general recommendations for the protection of such items of equipment as transformers, motors and feeders.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, June 28.—OXFORD, READING AND DISTRICTS BRANCH : Visit to London Airport.

Wed., July 3.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Exhibitions and Displays," D. V. Durling, 7 p.m.

Sat., July 6.—OXFORD, READING AND DISTRICTS BRANCH : Visit to the Atomic Energy Research Establishment, Harwell.

BRITISH INSTITUTION OF RADIO ENGINEERS

Mon., July 1.—Clerk Maxwell and Green Lecture Theatres, Cavendish Laboratory, University of Cambridge, Convention on "Electronics in Automation."

BRITISH INTERPLANETARY SOCIETY

Thurs. to Sat., July 18 *to* 20.—JOINT MEETING WITH THE COLLEGE OF AERONAUTICS : College of Aeronautics, Cranfield, Symposium on "High Altitude and Satellite Rockets."

CHEMICAL SOCIETY

Mon. to Tues., July 8 *to* 9.—Queen's Building, Queen Mary College, London, Symposium on "Solvent Effects and Reaction Mechanism."

Thurs. to Fri., July 11 *to* 12.—Chemistry Department, University of Glasgow, Symposium on "Recent Advances in the Chemistry of Terpenoid Compounds."

INSTITUTE OF THE MOTOR INDUSTRY

Sat. to Sat., Aug. 24 *to* 31.—St. Catharine's College, Cambridge, Eleventh Annual Summer School.

INSTITUTE OF PETROLEUM

Tues., July 9.—26, Portland Place, London, W.1, "Hydrocarbons from Petroleum," Frederick D. Rossini, 4.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., July 18.—LONDON BRANCH : Day Visit to the Factory of de Havilland Aircraft Company, Ltd., Hatfield, Herts.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, June 28.—EDUCATION DISCUSSION CIRCLE : Northampton Polytechnic, St. John Street, London, E.C.1, Exhibition of Apparatus for Teaching Electrical Engineering, 6–8.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., June 29.—S. GRADUATES' SECTION : Visit to National Gas Turbine Establishment, Pyestock, Farnborough, Hants.

Wed., July 17.—S. WALES BRANCH : Visit to Rank Precision Industries (B.A.F.), Ltd., Mitcheldean, Gloucester.

Wed., July 24.—N.W. BRANCH : Visit to Calder Hall Nuclear Power Station.

Sat., Aug. 31.—S. BRANCH : Whole-day Visit to the Pumping Stations of the Mid-Wessex Water Company, Frimley, Surrey.

INSTITUTION OF NAVAL ARCHITECTS

Tues. to Thurs., July 9 *to* 11.—Summer Meeting in Bristol.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

To-day and Sat., June 28 *and* 29.—SUMMER MEETING : To-day at Caxton Hall, Westminster, London, S.W.1, Annual General Meeting, 4.45 p.m. ; "Ashford Common Filtration Works of the Metropolitan Water Board," F. Tattersall, 6 p.m. ; Saturday, Visit to Ashford Common Filtration Works, Middlesex.

PLASTICS INSTITUTE

Fri., July 19.—Conference Room, Gallery, National Hall, Olympia, London, W.14, Annual General Meeting, 12 noon.

ROYAL METEOROLOGICAL SOCIETY

Wed. to Fri., July 3 *to* 5.—Department of Natural Philosophy, University of Glasgow, Summer Meeting.

END OF VOLUME 203

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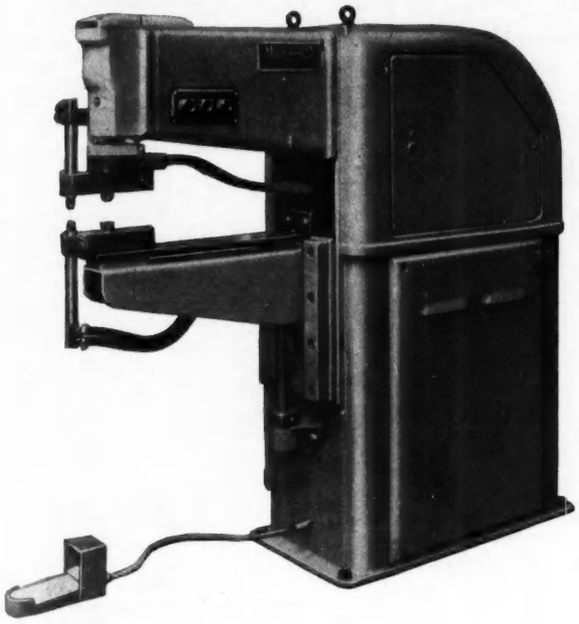

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Vol. 203 No. 5292

JUNE 28, 1957

Published every Friday Registered as a Newspaper

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SALE & VALUATION

OF

FACTORIES

PLANT AND MACHINERY

20, Hanover Square, W.1.

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E R

By order of the MINISTER OF SUPPLY. Messrs.

FULLER, HORSEY,
Sons & Cassell

have been instructed to offer for SALE by AUCTION in Lots at the ROYAL ARSENAL, WOOLWICH, LONDON, S.E.18, on TUESDAY, 9th JULY, 1957, and following days at 10.30 a.m. precisely each day,

ENGINEERS' MACHINE TOOLS
MOTOR VEHICLES,
INDUSTRIAL EQUIPMENT
AND SURPLUS STORES

including : Brown & Sharpe NO. 2 SURFACE GRINDER ; Drummond MAXICUT LATHE ; Vomag HORIZONTAL BORING MACHINE ; Herbert NO. 1 and NO. 3ND MOTORISED PLAIN HORIZONTAL MILLING MACHINES ; S.S. & S.C. Lathes ; Capstan and Turret Lathes ; Drilling & Shaping Machines ; 500 VEHICLES, including Limousines, Saloons, Humber and Ford Utilities ; 3-ton Trucks, 3-40-ton TRAILERS, 39 6-ton ARTICULATED TRAILERS, WITH BED-FORD SCAMMELL ATTACHMENT ; 56 INDUSTRIAL TRAILERS, TRACTORS and TRUCKS ; 21 TRANSPORTING CARRIAGES and LIMBERS ; 2 PACIFIC TYPE M 26 PETROL TRACTORS ; 25 tons M.T. Spares ; Jaeger POWER MODEL AGGREGATE SPREADER ; Wingate NO. 2 PORTABLE ROLLER PAN MORTAR MIXER ; PRIESTMAN 6-ton MOBILE DIESEL CRANE ; MOBILE AIR COMPRESSOR PLANTS ; Paint Spraying Tyre Inflation & Lubricating Compressor Plants ; 300 DIESEL & PETROL-ELECTRIC GENERATING SETS ; 146 TRAILER MOUNTED GENERATING SETS ; 700 Petrol Electric 80-watt Charging Sets ; 5 tons BALL BEARINGS ; Pipe Grooving Machines and Engineers' Tools ; large quantity NOS. 19 and 38 WIRELESS SETS ; Wireless and Electrical Stores ; large quantity TELEPHONE CABLE ; 55 tons scrap Radar Fittings ; scrap Blankets, Canvas, Webbing and Armoured Hose ; 35 tons DRAG-ROPES ; Service and Civilian Clothing and Footwear ; large quantity of 1" Leather and Web Straps ; large quantity of Barrack Room Furniture ; large quantity Prismatic Binoculars, Telescopes and Periscopes, Recording Paper and Ink and numerous othe effects.

Catalogues, 6d. each, admitting two persons on view days (Wednesday, Thursday, Friday and Monday preceding Sale) and one on Sale Days, may be had, when ready, from the AUCTIONEERS' OFFICES, 10, Lloyds Avenue, London E.C.3.

E7201 J

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of
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Twenty-ninth Sale.

E R

By Order of the Secretary of State for Air.
NO. 25 MAINTENANCE UNIT, ROYAL AIR FORCE, HARTLEBURY. Worcestershire.
4 miles from Kidderminster, 11 miles from Worcester.

Nock & Joseland
are Instructed to SELL by AUCTION at the above UNIT, on

THURSDAY. 4th JULY, 1957,
at 11 a.m. prompt.

A Large Quantity of Valuable MISCELLANEOUS STORES including :

CLOTHING & EQUIPMENT.
PARACHUTES & DINGHIES.
CAMERAS & PHOTOGRAPHIC EQUIPMENT.
RADIO & ELECTRICAL EQUIPMENT.
FOOTWEAR & REPAIR MATERIALS.
METAL FITTINGS.
GENERAL STORES

VIEWING :

The Lots are on view at Hartlebury on Wednesday, 3rd July, 1957, between the hours of 9 a.m. and 4 p.m., and on the morning of the Sale Day between the hours of 8 a.m. and 11 a.m.

Admission by Catalogue only, price Sixpence each (Postal Orders NOT Stamps), which can be obtained from the Auctioneers :

Nock & Joseland, Bank Buildings, Kidderminster. (Tel.: 2053 and 4211.) E7120 J

ERS&K

27th Collective Machinery Sale
Vinery Works,
96, Town Lane, Denton,
Manchester.

Edward Rushton Son & KENYON will SELL BY AUCTION on THURSDAY, JULY 11th, at 10.30 a.m. prompt, the miscellaneous

MACHINERY & PLANT

including Bullard 24in. vert. turret lathe ; Foster 4in. turret lathes ; Hasse & Wrede 3in. ditto ; Acme No. 3 semi-universal turret lathe ; Herbert 2S capstan lathe ; 4in. capstans ; various centre lathes ; Myford bench lathe ; Cincinnati No. 3 plain horiz. miller ; universal vert. milling attachment ; Gleason 10in. gear cutter ; Torpex shaper ; Landis plain grinder ; Churchill surface grinder 48in. by 7in. ; Sundstrand tool grinder ; bench grinders ; Lumsden grinder ; Morrisflex grinders ; Richards No. 2 keyseater ; Turner thread miller ; Thiel tapping m/c. ; Pollard 3ft. radial drill ; pillar and bench drills hacksawing m/cs. ; arbor and flypresses ; Smith sawbench 38in. by 27in. ; bench type saw ; bandsaws ; bench belt sander ; ripsnorter ; polishing spindles ; Rumbler ; Vickery 52in. sheet metal folding m/c. ; Westwood 42in. by 14 S.W.G. bending rolls ; 36in. by 16 S.W.G. treadle guillotine ; 50in. bench folding m/c. ; Besco 30in. angle benders ; tube benders ; Tilghman sandblast cabinets ; air compressors ; pumps ; various reduction gears ; various large welding generators ; 5kVA spot welders ; unused 55 h.p. Hill diesel engine ; 9½kVA petrol generator ; Slingsby electric stacker ; Yale 10 cwt. stacker ; hand jib crane ; friction hoist ; lifting tackle ; weighing m/cs. ; 120 electric motors up to 170 h.p. ; transformers and switchgear ; engineers small tools ; new surface plates and tables ; angle plates ; demagnetiser ; H.p. portable oilers ; steam valves ; steel cupboards and racks ; s.s. sterilizer ; industrial vacuum cleaner ; lorry sheets and tarpaulins ; rubber hose ; shovels ; electric lamps and fluorescent fittings ; handbag frames ; sewing m/cs. 31K15 and 31K22 ; Mardrive & Reece units ; machine benching and fittings ; new binoculars, &c.

On View : July 4th, 5th, 6th, 8th, 9th and 10th, from 9 a.m. to 5 p.m. (noon on Saturday) and on morning of sale.

Catalogues from the Auctioneers, 12, York Street, Manchester, 2. Tels.: CENtral 1937/9. E7264

CLASSIFIED ADVERTISEMENTS

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BUSINESSES and PREMISES • MISCELLANEOUS • PUBLIC APPOINTMENTS
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Copy Date. "Run-on" and "Semi-Displayed"—by noon on Tuesday for publication on Friday of the same week.
"Displayed" and "Illustrated"—by noon on Friday for publication on the following Friday.

For styles and sizes of "Run-on", "Semi-Displayed", "Displayed" and "Illustrated" Classified Advertisements please send for Circular.

Advertisements for publication should be addressed to:—
Classified Advertisement Dept.,
"The Engineer", 28 Essex Street, Strand, London, W.C.2.
Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

LOUGHBOROUGH COLLEGE OF TECHNOLOGY, LEICESTERSHIRE

Principal: H. L. HASLEGRAVE, Wh.Sc. M.A. (Cantab), Ph.D. (London), M.Sc. (Eng.), M.I.Mech.E., M.I.E.E., M.I.Prod.E.

DEPARTMENT OF WORKSHOP TRAINING AND PRACTICE

APPOINTMENTS

Applications are invited for the following posts, which are new appointments to deal with increased training facilities :—

1. DESIGN AND DEVELOPMENT ENGINEER.
2. PRODUCTION ENGINEER.
3. ASSISTANT INSTRUCTOR, Drawing-Office.
4. ASSISTANT INSTRUCTOR, Pattern Shop.
5. ASSISTANT INSTRUCTOR, Welding Shop.
6. ASSISTANT INSTRUCTOR, Machine Shop.

The Department gives comprehensive practical training to full-time engineering students. The products include gas engines, steam engines, hydraulic testing machines and a wide range of engineering laboratory apparatus.

The successful applicants will be required to instruct students in the work of the particular section to which they are appointed.

The Design and Development Engineer will be responsible for the training of students in the design of new products, the improvement of existing designs and the testing of finished products.

The Production Engineer will be required to instruct and control students in the workshops on production planning and control, work measurement, metrology and inspection.

Applicants should be Mechanical Engineers who have had good practical training and industrial experience. They should be well qualified, and teaching experience, though not essential, is desirable.

Salaries will be paid according to the following scales :—

Post 1, £1200 by £30 to £1350 per annum.
Post 2, £650 by £25 to £1025 per annum.

Starting salary within this range will be fixed according to experience and qualifications.

Posts 3, 4, 5 and 6, £800 by £25 to £900.

All posts are pensionable under the Teachers' or Local Government Superannuation Scheme.

Application forms and further particulars may be obtained from The Registrar, to whom completed applications should be sent as soon as possible. E7220

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG, SOUTH AFRICA

DEPARTMENT OF ELECTRICAL ENGINEERING

SENIOR LECTURER AND LECTURER

Applications are invited for the positions of SENIOR LECTURER and LECTURER on the staff of the Department of Electrical Engineering.

Senior Lecturer : applicants must be able to teach electrical machine theory, power circuit theory, and to give laboratory instruction in the electrical machine theory. The Department has facilities for research in electrical machines and in high-voltage electrical engineering.

Lecturer : applicants must be able to teach general telecommunications and network theory, and electromagnetic theory. He will also be required to give laboratory instruction in the telecommunications and electronics laboratories.

Salary scales : Senior Lecturer, £1200 by £50 to £1500 per annum ; Lecturer, £850 by £50 to £1200 per annum.

Cost-of-living allowance : payable in terms of Union Government regulations to persons with dependants. The present rate for a married man is £234 per annum.

Membership of the University Institutions' Provident Fund is compulsory and involves a contribution at the rate of 7 per cent of the salary paid. Membership of the Staff Medical Aid Fund is obligatory in the case of an officer who is eligible for membership in terms of the rules of the fund.

Applicants are advised to obtain a copy of the information sheet relating to these vacancies from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close in South Africa and London on 12th August, 1957. E7214

COLLEGE OF TECHNOLOGY, BIRMINGHAM (DESIGNATED COLLEGE OF ADVANCED TECHNOLOGY)

DEPARTMENT OF INDUSTRIAL ADMINISTRATION

LECTURER IN PRODUCT DEVELOPMENT

Applications are invited for the new appointment of LECTURER IN PRODUCT DEVELOPMENT, with special reference to Organisation and Management of Product Design Departments in Manufacturing Industry.

Candidates should be of Graduate or professional status, with experience of supervising design and development project work.

Salary in accordance with the Burnham scale : £1200 by £30 to £1350 (men).

Further information may be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1, to whom completed applications should be sent not later than 14 days after publication of this advertisement.

K. R. PILLING,
E7271 Clerk to the Governing Body.

KUMASI COLLEGE OF TECHNOLOGY

(Principal: W. E. DUNCANSON, Ph.D., D.Sc., F.Inst.P., A.M.I.E.E.)

SCHOOL OF ENGINEERING

APPOINTMENTS

Applications are invited for the posts of SENIOR LECTURER/LECTURER in

(1) Soil Mechanics and Geology ;
(2) Metallurgy and Strength of Materials ;

in the School of Engineering.

Students are prepared for the B.Sc. (Eng.) Degree of London University.

The Laboratories of the School are well equipped with modern machinery. Excellent research facilities are available.

The appointments will be made in the Grade of Senior Lecturer or Lecturer, depending upon the qualifications and experience of the candidates.

SALARY SCALES

Senior Lecturer : £1500 by £60 to £1850 p.a., plus £200 non-pensionable allowance.

Lecturer : £880 by £50 to £1560 p.a., plus £150 non-pensionable allowance.

Children's allowances up to a maximum of three at the rate of £50 p.a. per child up to the age of 10 years and £100 p.a. per child over 10 years of age in full-time education up to a maximum of 21 years.

The posts are pensionable, but contract appointments carrying 25 per cent higher salary and a gratuity of £150 p.a. may be accepted as an alternative, or arrangements to continue policies initiated under the F.S.S.U. scheme might be made by the College.

Conditions of service include annual leave with free return 1st class passages for the member of staff, his wife, and up to 3 children under 17 years. Bungalows with basic furniture at nominal rent are provided. Income tax is low.

Applications (6 copies) should be submitted to the Advisory Committee on Colonial Colleges, 1, Woburn Square, London, W.C.1, giving age, education, qualifications, experience and the names of three referees. Closing date, 25th July, 1957. E7270

LOUGHBOROUGH COLLEGE OF TECHNOLOGY, LEICESTERSHIRE

Principal : H. L. HASLEGRAVE, Wh.Sc., M.A. (Cantab.), Ph.D. (Lond.), M.Sc. (Eng.), M.I.Mech.E., M.I.E.E., M.I.Prod.E.

DEPARTMENT OF WORKSHOP TRAINING AND PRACTICE

APPOINTMENTS

Applications are invited for the following vacancies caused by retirement of staff :—

1. SUPERINTENDENT, CAPSTAN/AUTO. SHOP.
2. INSTRUCTOR in MACHINE SHOP.

The persons appointed will be required to give practical instruction on a production basis to full-time engineering students. Applicants should be well qualified and good industrial experience is essential. Teaching experience, though not essential, is desirable.

Salaries will be paid according to the following scales :—

Post 1, £650 by £25 to £1025. Starting salary within this range will be fixed according to experience and qualifications.

Post 2, £800 by £25 to £900.

Further particulars and application forms may be obtained from the Registrar. E7256

UNIVERSITY OF WESTERN AUSTRALIA

LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for the position of LECTURER IN ELECTRICAL ENGINEERING. Applicants should hold a Degree in Engineering and preference will be given to an applicant with experience or interest in some aspect of heavy power electrical design.

The salary range for Lecturers is £A1250–£A1750 per annum, plus cost-of-living allowance (at present £43 p.a.) ; the commencing salary will be determined on the basis of the qualifications and experience of the appointee.

An allowance is made towards travelling expenses and housing assistance is available.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in Australia and London, is 14th August, 1957. E7215

READING TECHNICAL COLLEGE

LECTURER IN MECHANICAL ENGINEERING SUBJECTS

LECTURER IN MECHANICAL ENGINEERING SUBJECTS required for September next. Applicants should have good industrial and some teaching experience, and be able to teach a range of subjects up to H.N.C. level, preferably Theory of Structures. Degree or equivalent essential. Corporate Membership of Professional Institution preferred. Salary £1200–£1350.

Apply in writing, giving full particulars of qualifications and experience (including teaching, if any), to Chief Education Officer, Reading Education Office, Blagrave Street, Reading, within ten days of date on which this advertisement appears. E7227

UNIVERSITY OF CAPE TOWN

THE DEPARTMENT OF MECHANICAL ENGINEERING

SENIOR LECTURESHIP

Applications are invited for the SENIOR LECTURESHIP in the Department of Mechanical Engineering.

The salary scale is £1200 by £50 to £1500 per annum. There is also a temporary cost-of-living allowance for a married man (at present £234 per annum).

Applications (with copies of testimonials) should state age, qualifications, experience and research work completed or in progress and give the names of two referees whom the University may consult. Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1 (from whom memoranda giving the general conditions of appointment and further information about the work of the department should be obtained) not later than 7th August, 1957. An additional copy should be sent direct by air mail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa, by the same date.

The University reserves the right to appoint a person other than one of the applicants or to make no appointment. E7260

SOUTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART LONGBRIDGE ROAD, DAGENHAM

APPOINTMENTS

Required in September or as soon after as possible :

(a) LECTURER in MECHANICAL ENGINEERING, to teach Theory of Structures to Higher National Certificate level and Applied Mechanics to Ordinary National Certificate level. Salary, £1200 by £30 to £1350 per annum plus London allowance.

(b) GRADE "B" ASSISTANT LECTURER in PRODUCTION ENGINEERING, to teach Workshop Technology to Ordinary National Certificate and City and Guilds students. Salary, £650 by £25 to £1025, with additions for degree or equivalent and approved training. Increments within scale for previous teaching service, approved industrial experience, and war/National Service.

Details and application forms (stamped addressed foolscap envelope) from the Clerk to Governors at the College. E7293

CENTRAL ELECTRICITY AUTHORITY HEADQUARTERS

STATION PLANNING AND DEVELOPMENT BRANCH

ENGINEERS

Central Electricity Authority Headquarters require ENGINEERS in the Station Planning and Development Branch in London, S.E.1.

The Branch is responsible for (a) investigation and selection of sites for nuclear power stations, co-ordination of investigations and selection of sites for orthodox stations, negotiations for statutory and other consents for both classes of stations ; (b) formulation of initial basic designs of new orthodox power stations, including layout of sites and stations, railway sidings, circuiting water systems, development of works power supply schemes, plant control schemes.

All candidates should have an Honours Degree or qualifications for membership of the I.Mech.E., I.C.E. or I.E.E. and for (a) preferably experience of economic studies or of one or more of the problems arising in the siting of power stations, e.g., geology and ground exploration ; thermal and hydraulic aspects of the use of river and sea water for cooling purposes ; discharge and dispersal of chimney emissions ; questions of town and country planning. Candidates for (b) must be experienced in the design and layout of large modern power stations and associated plant, and experience of the construction or operation of such stations would be an advantage.

Salaries within scales : Senior Assistant Engineer, £1435–£1795 p.a.; Second Assistant Engineers, £1210–£1570 p.a.; Third Assistant Engineer, £1105–£1315 p.a.; Fourth Assistant Engineer, £870–£1045 p.a.

Application forms, obtainable from D. Moffat, Director of Establishments, Winsley Street, London, W.1, should be completed and returned by 11th July. Quote ref. ENR/281. E7255

FEDERATION OF MALAYA

PUBLIC WORKS DEPARTMENT

MECHANICAL ENGINEERS

To supervise and control the Department's Mechanical Workshops, vehicular transport, building and road construction plant, &c., also maintenance of water supply pumping stations.

Contract appointment. Salary range : £1240–£2378, point of entry depending on experience and war service. Substantial cost-of-living allowance. Contract gratuity of £58 to £81 p.a. for each completed three months' satisfactory service.

Gross emoluments for single man, minimum £1302, maximum £2120 ; married man minimum £1574, maximum £2499 ; married man with children, minimum £1665, maximum £2730.

Free passages for officer, wife and 3 children under age of 10. Quarters, if available, at reasonable rents. Generous leave.

Candidates, aged 25–35, must have passed or be exempt from Parts A and B of the examination for A.M.I.Mech.E., with at least four years' practical experience after qualifying and a good knowledge of diesel engines. Experience of road construction and earth-removing equipment would be an advantage.

Write, Director of Recruitment, Colonial Office, London, S.W.1, stating age, qualifications and experience, quoting BCD.112/23/01. E7204

WESTERN REGIONAL HOSPITAL BOARD, SCOTLAND

APPOINTMENTS

Applications are invited for the following appointments :—

DEPUTY REGIONAL ENGINEER

Applicants should be engineers of professional standing and should be Corporate Members of the Institution of Mechanical Engineers, Institution of Electrical Engineers, or Institution of Civil Engineers, with wide experience of all branches of hospital engineering, design and operation. The person appointed will be required to act for the Regional Engineer over the whole range of the services for which the Engineer is responsible and be able to advise the Board in the absence of the Regional Engineer. He will also be responsible for the day-to-day supervision of the Engineering Departments of the Board's works organisation. Salary scale, £1345 by £55 (2) by £50 (2) by £35 (1) to £1590.

ASSISTANT ENGINEERS

Applications are invited for two posts of Assistant Engineer for electrical and heating duties respectively. Applicants should be Corporate Members of, or have obtained, the technical standard of Corporate Members of the Institutions of Electrical Engineers or Heating and Ventilating Engineers respectively, and should have practical and theoretical experience of design, installation and operation and general maintenance and should be capable of assisting in preparing specifications and estimates and advising generally on the classes of plant in their own particular field, viz. :—

(a) Electrical : electrical installation, including heating, lighting and power, and

(b) Heating : heating, ventilating, hot water, air conditioning, refrigerating, sterilising and pipe work installations in large buildings, laundries, kitchens &c.

Salary scale : £680 by £25 (3) by £30 (2) by £35 (1) by £30 (1) by £35 (3) to £985.

CLERK OF WORKS (ELECTRICAL AND MECHANICAL)

Applicants should have served an apprenticeship in mechanical or electrical engineering, and have had not less than five years' experience supervising site installations, employing trades associated with mechanical, heating and ventilating and/or electrical engineering. Salary scale, £615 by £22 (2) by £25 (3) to £730.

The successful applicants will be required to pass a medical examination and all appointments are subject to a deduction at the rate of 6 per cent per annum for superannuation. In the case of the Deputy Regional Engineer, the appointment will be subject to three months' notice of termination on either side, and in the other appointments two months' notice on either side is required. Applications, giving particulars of qualifications and experience, together with the names of three referees, should be lodged with the Secretary, Western Regional Hospital Board, 64, West Regent Street, Glasgow C.2, not later than 20th July, 1957. E7225

AIR MINISTRY

WORKS DEPARTMENT

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS in Works Department for design, operation and maintenance of mechanical and electrical services on R.A.F. stations at home and overseas and Civil Aviation stations. Salary, according to age, £765 at 25 up to £1030 at 34 or over, thereafter rising to maximum £1190 London appointment ; somewhat lower in provinces. Promotion prospects. Appointments non-pensionable, but with pensionable prospects ; 5-day week, with 4–6 weeks' leave a year, according to length of service. Special allowance up to £1450 a year, according to location, payable in addition to salary during overseas service. Candidates normally must be natural born British subjects of natural born British parents and age 25 or over. Minimum qualifications and experience : (i) (a) University Degree or equivalent Diploma in Electrical and/or Mechanical Engineering with at least 2 years' apprenticeship, or (b) Graduate or Corporate Member of I.E.E., with at least 3 years' apprenticeship, or (c) Graduate or Corporate Member of I.Mech.E., appreciable electrical engineering experience with at least 3 years' apprenticeship, and (ii) have been employed for minimum of three years with well-established engineering concern and gained wide experience in both electrical and mechanical engineering practice.—Forms, quoting reference D 306/6A, from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1. E7064

CENTRAL ELECTRICITY AUTHORITY

EASTERN DIVISION

SENIOR DRAUGHTSMEN (MECHANICAL)

Applications are invited for the following appointments : SENIOR DRAUGHTSMEN (Mechanical), Generation (Construction) Department at Divisional Headquarters.

Salary N.J.B., Schedule "D," Grades 4/5, £735–£955 per annum.

The commencing salary will depend upon experience and qualifications, but will be within the above range.

Applicants must have had experience in mechanical plant layout, pipework design.

Applications, stating age, qualifications, experience and present position, should be addressed to the Controller, Central Electricity Authority, Eastern Division, Northmet House, Southgate, N.14.

W. N. C. CLINCH,
E928 Controller.

Classified Advts. continued on page 4

PUBLIC APPOINTMENTS

GLAMORGAN COUNTY COUNCIL

HIGHWAYS AND PLANNING DEPARTMENT

APPOINTMENTS

(a) ASSISTANT SURVEYOR (Traffic Engineering).
(b) CHIEF ASSISTANT (Roads Section).

Applications are invited for the above posts at a salary scale of £1145 by £65 by £55 (2) to £1320 per annum at the County Hall, Cardiff.

In certain cases a lodging allowance of £130 per annum, for a period not exceeding six months, may be paid.

The duties attaching to the posts will be :—

(a) To investigate and report on the problems of traffic flow in relation to both existing and new road capacity, accident investigation, road safety provisions, and the relationship of all these to road design.

(b) To be responsible under the Assistant Surveyor (Roads) for supervising the drawing-office engaged on the scheme preparation of major and minor road improvements and diversions and for controlling the work of survey parties.

Candidates must be Associate Members of the Institution of Civil Engineers and/or the Institution of Municipal Engineers, must have had a sound training and considerable experience in the appropriate branches of work, and will be required to provide and maintain a car, for which an allowance will be paid.

Applications, giving name, address, age, education, training, qualifications, and previous appointments with dates, experience in the above classes of work, and the names of three referees, to the County Surveyor, County Hall, Cardiff. Closing date, Wednesday, July 17th, 1957.

RICHARD JOHN,
Clerk of the County Council.
E7281

NATIONAL COAL BOARD

NORTH WESTERN DIVISION

APPOINTMENTS

DIVISIONAL CIVIL ENGINEER required. Salary range £1750 to £2500 per annum.

Applicants should be Corporate Members of the Institution of Civil Engineers or the Institution of Structural Engineers with equivalent experience. The person appointed will be responsible for the control of civil engineering work in the Division, including work on reconstruction schemes and the current construction of two new collieries. Experience in large-scale civil engineering work is essential and experience of colliery construction an advantage.

AREA CIVIL ENGINEER required. Salary range £1250 to £2000 per annum.

The Area contains a new sinking and several major reconstructions. Applicants should have extensive professional experience of civil and structural engineering work associated with industrial installations. Experience of colliery work will be an advantage. The person appointed will be responsible for control of all civil engineering work carried out within the Area, including complete execution by contract or otherwise of smaller projects and liaison with the Divisional Civil Engineer on major projects.

Applications, stating age, experience, qualifications, present post and salary, to the Staff Director, 40, Portland Street, Manchester, 1, within fourteen days.
E7261

CENTRAL ELECTRICITY AUTHORITY

RESEARCH LABORATORIES

APPOINTMENTS

Central Electricity Authority Research Laboratories, Leatherhead, Surrey, require : (1) SENIOR DRAUGHTSMAN for mechanical engineering design work on laboratory test rigs, pilot plant and prototype apparatus. Candidates should have H.N.C., good design experience and, preferably, knowledge of pressurised pipe and duct layouts. Salary : £895–£995 p.a., according to ability. (2) ENGINEERING DRAUGHTSMEN for a wide range of work, including general design of equipment and the preparation of diagrammatic layouts and wiring diagrams. Candidates should have H.N.C. or O.N.C. Previous laboratory experience not necessary. Salaries within ranges £595–£860 p.a., according to ability.

Applications, stating age, qualifications, experience, present position and salary, to D. Moffat, Director of Establishments, Winsley Street, London, W.1. by 5th July. Quote ref. ENR/267.
E7217

THE NATIONAL INDUSTRIAL FUEL EFFICIENCY SERVICE

ENGINEERING ASSISTANTS

The National Industrial Fuel Efficiency Service invites applications for posts as ENGINEERING ASSISTANTS. Candidates must have practical experience in the maintenance and control of steam-using plant or high temperature furnaces and have taken an approved course of study in the appropriate subject.

Vacancies exist in Leeds, Cardiff, Birmingham, Nottingham, Manchester and Glasgow Provincial Area Offices. Commencing salary will be in the scale £725 to £883 per annum.

N.I.F.E.S. Engineering Assistants are encouraged to make themselves eligible for promotion by obtaining the necessary qualifications.

Successful candidates will be required to serve a probationary period of not more than one year and will become members of the company's superannuation scheme after one year's service.

Application forms may be obtained from the National Industrial Fuel Efficiency Service, Dept. E.A., 71, Grosvenor Street, London, W.1. E7210

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

MINING RESEARCH ESTABLISHMENT

MECHANICAL ENGINEERS

MECHANICAL ENGINEERS required at N.C.B.'s Mining Research Establishment, Worton Hall, Isleworth, Middlesex, for research into many aspects of mining. There are vacancies (for which knowledge of mining is NOT necessary) in the following fields :—

(a) Investigation of applied mechanics problems forming the elements of mechanised coal-winning processes.

(b) Design of experimental machinery and other mining equipment and its subsequent test on the surface and underground.

(c) Research in specialist fields appropriate to those interested in elasticity, mechanisms, hydraulic control systems, structures and similar subjects.

(d) Design, construction and commissioning of test rigs.

Appointments, variously graded, within inclusive scales from £690–£1964 (Scientists) and £492–£1069 (Scientific Technical Officers). For the former grades good Honours Degree or equivalent qualification and relevant experience are essential, for the latter O.N.C. (Mechanical) or G.C.E. "A" level in 2 or 3 science subjects is required ; in some cases an apprenticeship with practical experience is necessary. Specialists are encouraged to keep abreast of their subjects and the opportunity exists for the publication of research results. For junior grades there are facilities for further education.

All posts are pensionable, carry good leave and sickness privileges, and offer excellent career prospects.—Write for application form to the Personnel Officer at the above address, marking envelope X782/D, before 8th July, 1957.
E7219

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT

ALDERMASTON, BERKSHIRE

ENGINEERS

ENGINEERS required by The Atomic Weapons Research Establishment, Aldermaston, Berkshire, for posts as Engineers (Main and Basic Grades) and TECHNICAL ASSISTANT, to be responsible for the operation of a water-moderated, high neutron flux reactor now being built. Before working up the reactor to full power appointees will take part in a zero energy experiment to determine the characteristics of a reactor core and its control system. Shift work may be necessary later.

Candidates should have served a recognised engineering apprenticeship. Engineers should be A.M.I.Mech.E. or E.E. ; Technical Assistants, Grad.I.Mech.E. or E.E., or have exempting qualifications.

Operating experience in power, steel, marine or chemical fields an advantage. These vacancies offer a good training ground to suitably qualified young engineers.

Salary : Engineer (Main Grade), £1235–£1655 p.a. ; Engineer (Basic Grade), £775 (at age 25) to £1060 (at age 34 or over) to £1210 p.a. ; Technical Assistant, £540 (at age 20) to £920 (at age 30) p.a. Contributory superannuation scheme.

A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Postcards for application forms to Senior Recruitment Officer at above address. Please quote reference 1521/25.
E7202

CITY OF LIVERPOOL

WATER DEPARTMENT

ASSISTANT (CIVIL ENGINEERING)

Applications are invited for the appointment of ASSISTANT (CIVIL ENGINEERING), Vyrnwy Aqueduct and Works Section, under the Resident Engineer, Oswestry. Salary, £543 5s. to £861 per annum, according to qualifications and experience (A.P.T. I/II, N.J.C. Scale).

Applicants must either have been trained as a civil engineer and have passed Part I and Part II of the Examination of the Institution of Civil Engineers (or hold the necessary exempting qualifications), or hold a suitable Degree of a British University. Experience in the construction or design of works of water supply an advantage.

Application forms, returnable by 15th July, from the Water Engineer, 55, Dale Street, Liverpool, 2. The appointment is superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

THOMAS ALKER,
Town Clerk.
Municipal Buildings,
Liverpool, 2 (J.4832).
E7280

THE NATIONAL INDUSTRIAL FUEL EFFICIENCY SERVICE

ASSISTANT ENGINEER

The National Industrial Fuel Efficiency Service invites applications from qualified Mechanical, Chemical, Heating and Ventilating Engineers or Fuel Technologists for posts in the basic professional grade of ASSISTANT ENGINEER. Industrial experience will be an advantage.

Vacancies exist in London and Leeds, Cardiff, Glasgow and Belfast Provincial Area Offices. Commencing salary in London will be in the scale £967 to £1432 p.a., and elsewhere £932 to £1362 p.a. Opportunities for promotion to senior posts will arise.

Successful candidates will be required to serve a probationary period of not more than one year and will become members of the company's superannuation scheme after one year's service.

Application forms may be obtained from the National Industrial Fuel Efficiency Service, Dept. A.E., 71, Grosvenor Street, London, W.1. E7211

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY AUTHORITY HEADQUARTERS

CHIEF ENGINEER'S DEPARTMENT

APPOINTMENTS

Required, in the drawing-office of the Chief Engineer's Department, Bankside House, Sumner Street, S.E.1 : (a) for civil and building work, (b) Electrical layouts and schematic diagrams :

(a) SECTION LEADER ; salary scale, £1070–£1170 p.a.
(a) and (b) SENIOR DRAUGHTSMAN (Grade 4) ; salary scale £945–£1045 p.a.
(a) and (b) SENIOR DRAUGHTSMAN (Grade 5) ; salary scale, £800–£910 p.a.
(a) and (b) ENGINEERING DRAUGHTSMAN; salary scale, £635–£755 p.a.

Salary according to ability and experience.

Permanent pensionable appointments. One Saturday morning in eight on duty. Canteen, sports and social club facilities.

Applications in writing to, or application forms can be obtained from, D. Moffat, Director of Establishments, Winsley Street, London, W.1. Quote ref. ENR./271.
E7229

METROPOLITAN BOROUGH OF WOOLWICH

BOROUGH ENGINEER'S DEPARTMENT

ASSISTANT ENGINEER

ASSISTANT ENGINEER required, Grade VI-VII, commencing at £902, rising to £1230, plus London Weighting. Experienced in either structural work—reinforced concrete and steelwork—or general municipal engineering. Must possess appropriate qualifications.

Medical examination. Superannuation scheme.

Applications (stating age, qualifications and experience, and giving two referees) to Town Clerk, Woolwich, S.E.18, by 15th July, 1957.
Canvassing disqualifies.
E7295

NATIONAL COAL BOARD

NORTH EASTERN DIVISION

CARBONISATION ENGINEERS

CARBONISATION ENGINEERS required at Carbonisation Group Headquarters at Sheffield, Rotherham and Wakefield. Salary £575/£1025 or £900/£1250, according to qualifications and experience.

Applicants must be fully conversant in the installation and maintenance of modern coke oven and by-product plant. A recognised qualification in engineering is desirable.

Apply to Administrative Officer, Carbonisation Department, Standfield House, Fulwood Road, Sheffield, 10, by 10th July.
E7252

TENDERS

SCOTTISH HOME DEPARTMENT

LONDON-CARLISLE-GLASGOW-INVERNESS TRUNK ROAD, A.74

PADDY'S RICKLE BRIDGE, LANARKSHIRE

The Secretary of State invites TENDERS for the CONSTRUCTION of a NEW CONCRETE SKEW BRIDGE over the Carlisle-Glasgow Railway, 4 miles south of Crawford, together with the REALIGNMENT of a SECTION of the Carlisle-Glasgow Trunk Road A.74, and works ancillary thereto.

Contract documents may be obtained from Messrs. Babtre, Shaw and Morton Chartered Civil Engineers, 17, Blythswood Square, Glasgow, C.2, upon payment of a deposit of £15 by cheque made payable to the order of the Queen's and Lord Treasurer's Remembrancer. The deposit will be returned if a bona-fide Tender is submitted and not subsequently withdrawn.

Drawings may be seen at the office of the Consulting Engineers.

Tenders on the official form, which must be received before 4 p.m. on 31st July, 1957, should be sent in a sealed registered envelope, marked "Paddy's Rickle Bridge Tender," addressed to the Secretary, Scottish Home Department, Broomhouse Drive, Saughton, Edinburgh, 11.

The Secretary of State does not bind himself to accept the lowest or any Tender.
E7257

GOVERNMENT OF IRAQ

ELECTRIFICATION OF BASRAH POWER PROJECT

CONTRACT NO. (5)

TURBINE HOUSE AND AUXILIARY CRANES

The Development Board and Ministry of Development of the Government of Iraq invite TENDERS from qualified firms for the SUPPLY and DELIVERY of TURBINE HOUSE and AUXILIARY CRANES for Basrah Power Station.

Full information regarding this Tender can be obtained on and after June 10, 1957, from Iraqi Embassy, London, or Messrs. Ewbank and Partners, 10-11, Grosvenor Place, London, S.W.1, England.

All Tender documents are to be submitted in English to the Ministry of Development, on or before 12 noon, local time, on August 5, 1957.
E7068 MINISTER OF DEVELOPMENT.

TENDERS

CHESTERFIELD, BOLSOVER AND CLOWNE WATER BOARD

RESERVOIRS (SAFETY PROVISIONS) ACT, 1930

LINACRE RESERVOIRS—CONTRACT A]

The Board invite TENDERS for the RECONDITIONING, under the above Act, of the LINACRE RESERVOIRS, which are impounding reservoirs formed by earthwork embankments, and are situated about 2½ miles west of Chesterfield, in the County of Derby.

The embankments of all three reservoirs are to be increased in height. At the upper reservoir, a new waste weir and watercourse and valve shaft house and bridge are to be constructed. At the middle reservoir, a new waste weir and watercourse is to be constructed. At the lower reservoir a new waste weir and watercourse and a new footbridge are to be constructed.

Plans and drawings may be seen and the general conditions, specification and form of Tender obtained, on application to G. H. Hill and Sons (Manchester), Civil Engineers, 51, Mosley Street, Manchester, 2, upon deposit of a cheque for Five Guineas. This sum will be returned to the Tenderer provided that he shall have submitted a bona fide Tender which shall not have been withdrawn.

Copies of the drawings are available and, if the Tenderer so desires, will be supplied to him on payment of a sum of One Guinea, which will not be returned.

Separate cheques should be sent, made payable to G. H. Hill and Sons (Manchester).

Sealed Tenders, endorsed "Tenders for Linacre Reservoirs, Contract 'A']" and addressed to the Clerk to the Chesterfield, Bolsover and Clowne Water Board, Town Hall, Chesterfield, must be delivered not later than noon on the seventh day of September, 1957.

The Board do not bind themselves to accept the lowest or any Tender.

RICHARD CLEGG,
Clerk to the Board.
Town Hall,
Chesterfield.
E7268

STAFFORDSHIRE POTTERIES WATER BOARD

HEAVY DUTY GENERAL PURPOSE LATHE

TENDERS are invited for the SUPPLY and DELIVERY of ONE New Motor-Driven All-Geared Heavy Duty General Purpose Gap Bed, Sliding, Surfacing and Screwcutting LATHE, complete with faceplate, coolant pump and fittings. Height of centres 8¾in. Length of bed 8ft. Second-hand or reconditioned lathes will not be considered.

The general conditions of contract, specification, schedule of prices and form of Tender may be obtained from the undersigned and the completed schedule of prices and form of Tender returned in the envelope provided, but not bearing any name or mark indicating the sender, and endorsed "Tender for Lathe," not later than twelve noon on Monday, the 15th July, 1957.

The Board do not bind themselves to accept the lowest or any Tender.

C. V. BROWN,
Engineer and Manager and Clerk.
Albion Street, Hanley,
Stoke-on-Trent.
E7262

GOVERNMENT OF IRAQ

ELECTRIFICATION OF NORTHERN AND CENTRAL IRAQ

CONTRACT NO. 16 ELECTRICAL EQUIPMENT

The Development Board and Ministry of Development of the Government of Iraq invite TENDERS from qualified firms for the SUPPLY and DELIVERY of the ELECTRICAL EQUIPMENT for the Dibis and Baghdad Power Stations.

Full information regarding this Tender can be obtained on and after June 3rd, 1957, from Embassy of Iraq, London, or Electrobel-Traction et Electricité, 1, Place du Trone, Brussels, Belgium.

All Tender documents are to be submitted in English to the Ministry of Development, on or before 12 noon, local time, on August 5th, 1957.
E7158 MINISTER OF DEVELOPMENT.

EDUCATIONAL

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29 WRIGHT'S LANE, LONDON, W.8.
E102

EDUCATIONAL

UNIVERSITY OF EDINBURGH

POST-GRADUATE SCHOOL OF APPLIED DYNAMICS

A POST-GRADUATE COURSE, leading to the DIPLOMA IN APPLIED DYNAMICS, will be given in the Department of Engineering, commencing on 8th October, 1957, and ending in June, 1958. The Course will provide specialised training for Graduates who are working, or who intend to work, on dynamical problems. Applicants should hold an Honours Degree in Engineering, Mathematics or Physics.

The main Lecture Courses will be in Dynamics of Solids, Analytical Methods, Mechanical Vibration Gyrodynamics, and Theory of Control Systems. Laboratory work in the field of Applied Dynamics will also be undertaken.

A limited number of grants will be awarded to suitable candidates.

Further particulars and forms of application may be obtained from the Secretary to the University, Old College, South Bridge, Edinburgh, 8.

CHARLES H. STEWART,
Secretary to the University.

April, 1957. E6271 B

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guaranteed Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London W.8. E721 B

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

A DIE DESIGNER is required by a large foundry in the outer London area. Applicants should possess a thorough experience in pressure die casting techniques. Commencing salary will be assessed within the scale of £800 to £900 per annum. Staff superannuation scheme is in operation.—BOX No. E7169, "The Engineer." A

A VACANCY EXISTS for a FIRST-CLASS DESIGNER with wide experience in the light and precision engineering field. The successful applicant may be a Graduate Mechanical Engineer with progressive outlook and at least seven years' design experience in a senior capacity, preceded by practical experience or apprenticeship. He will be required to produce complete prototype designs to a specification and contribute clear thought and new ideas.—Apply to: Mr. D. H. Squire, Cricklewood Works, N.W.2. GLA. 3333. E7288 A

A VACANCY EXISTS for a GRADUATE MECHANICAL ENGINEER in the Development Department of Smiths Motor Accessories Ltd. The successful applicant will be a man who gets things done. His background must include an apprenticeship or practical experience, drawing-office and design experience, and at least five years' development experience with light precision engineering.—Apply to: Mr. D. H. Squire, Cricklewood Works, N.W.2. GLA. 3333. E7289 A

A YOUNG ELECTRONICS ENGINEER with some experience of (or particular interest in) digital computer design, character recognition and/or mechanised accounting, is invited to join a small group now being formed at the Bank of England Printing Works to apply these techniques to certain operations where a very large volume of documents has to be handled. The work will include preparation of original schemes and their development into reliable working systems, also supervision of some development contracts. Starting salary up to £1150 (including a cost-of-living payment).

A MECHANICAL DESIGN DRAUGHTSMAN with experience in the design of small mechanisms and preferably with some electrical knowledge, is also needed for this group. Starting salary up to £960 (including a cost of living payment). Pensionable employment. Housing Loan facilities in approved cases.—Apply in writing, stating full details of age, education, qualifications and experience, to the Staff Manager, Bank of England Printing Works, Loughton, Essex. E7047 A

AN ASSISTANT to the STANDARDS ENGINEER is required by MONSANTO CHEMICALS LIMITED. The work involves compiling specifications and investigations into the standardisation of machinery, equipment and materials for the chemical industry. Some workshop and/or drawing-office experience is required and an H.N.C. (Mechanical Engineering) is desirable. Experience of engineering in the chemical industry and on standards work would be an advantage.—Full details of age, education, training and experience, should be sent to the Chief Personnel Officer, Monsanto Chemicals Limited, 10–18, Victoria Street, London, S.W.1. E7243 A

APPLICATIONS are invited for the position of AREA CHIEF CIVIL ENGINEER in the East Midlands Division, No. 5 Area, Eastwood. Applicants must be qualified and must possess a wide experience in the layout and construction of buildings, roads, railway sidings and other civil works required for collieries and ancillary undertakings. Experience in the preparation of specifications, site preparation and supervisory control of operations is essential. Salary will be in accordance with experience, qualifications and ability within a range of £1250 to £2000.—Applications, stating age, qualifications and experience, should be sent to the Staff Manager, National Coal Board, East Midlands Division, No. 5 Area, Eastwood, Notts. within 14 days. E7212 A

ARCHITECTURAL DRAUGHTSMEN are required, with civil engineering experience, for the design of industrial buildings, offices and laboratories. Generous salaries will be paid commensurate with experience and ability. Five-day week and superannuation scheme.—Applications, which will be treated in confidence, should give previous experience and qualifications, and be addressed to the Chief Draughtsman, Laporte Chemicals, Ltd., Clifton House, Euston Road, London, N.W.1. E6899 A

AN EXPANDING AND LIVELY medium-sized company in the West of Scotland, enjoying an international reputation and engaged in light precision engineering, invites applications from ENGINEERING GRADUATES or those similarly qualified, who have practical experience in modern production engineering techniques and the capacity to qualify, after a period of training, for a position in Engineering Management. The work, in addition to carrying prospects for further advancement, is in itself extremely interesting and provides contact with a wide range of engineering, metallurgical and managerial activities. It is supported by the resources of the company's well-established Technical Division. The factory, which is a modern one situated close to the Ayrshire coast, provides a pleasant working environment. A generous salary, superannuation benefits and possibly some assistance with housing, awaits the successful applicant. Applications, which will be treated in strict confidence, should contain full details of age, qualifications, experience to date, present position and salary, and should be sent to.—BOX No. E7245, "The Engineer." A

APPLICATIONS invited from Chartered Civil Engineer with experience of maritime works, for post of RESIDENT ENGINEER on coast protection works, Kent. Gross salary £1150 Interview by appointment.—Messrs. Lewis and Duvivier, 122, Victoria Street, Westminster, S.W.1. E7285 A

W. S. ATKINS & PARTNERS ANNOUNCE

that they have a large amount of interesting and varied work in their Civil Engineering Department and are willing to engage design and drawing-office staff of all grades from Draughtsmen to Senior Engineers for work in London, Birmingham or Cardiff. Appointments carry good salaries, generous holidays, pension scheme and luncheon vouchers, and excellent prospects of advancement. There are some non-pensionable vacancies carrying correspondingly higher salaries.—Apply in writing, giving full details of previous experience and technical qualifications, if any, to 158, Victoria Street, London, S.W.1. E967 A

BRITISH-AMERICAN TOBACCO COMPANY, Limited, wish to recruit for vacancies in their new Research Centre at Southampton. Enquiries are invited from GRADUATES between 24 and 28, with some research experience in organic or physical chemistry and MECHANICAL ENGINEERS of the same age, with a sound knowledge of physics or electronics. These appointments are concerned with an interesting field of investigation and carry excellent salary, conditions and prospects.—Apply by letter to Personnel Manager, British-American Tobacco Company, Limited, Westminster House, 7, Millbank, London, S.W.1. E7248 A

BRITISH PETROLEUM COMPANY, LTD., has a vacancy for a CIVIL/CONSTRUCTION ENGINEER. Applicants, aged 30–40, must have A.M.I.C.E. or equivalent or A.M.I.Struct.E., and have practical experience of the design, detailing and construction of a wide variety of industrial steel structures, preferably with a reputable firm of Constructional Engineers. Practical knowledge of concrete design an additional advantage. Salary according to qualifications and experience. Non-contributory pension fund and assisted house purchase scheme. Removal expenses and settling-in allowances paid in certain cases. Luncheon club.—Write, giving full particulars, quoting H.3886C, to BOX 5294, c/o 191, Gresham House, E.C.2. E7234 A

BRITISH PETROLEUM COMPANY, LTD., has a vacancy for a CIVIL ENGINEER. Applicants aged 35 45, must have A.M.I.C.E. and a Degree in Civil Engineering is desirable. Must have had sound all-round civil engineering experience with an industrial background, including the design and construction of foundations for heavy and medium plant and of retaining walls, earth embankments, &c. Knowledge of Oil Terminal Installations and pipeline routing an additional advantage. Salary according to qualifications and experience, non-contributory pension fund, housing scheme. Removal expenses and settling-in allowances paid in certain cases.—Write, giving full particulars, quoting H.3886B, to BOX 5298, c/o 191, Gresham House, E.C.2. E7235 A

BRITISH PETROLEUM COMPANY, LTD., has a vacancy at its Head Office in London for a DIESEL ENGINEER with experience in engine design and development. The post entails liaison with diesel manufacturers and users, with particular reference to the utilisation of fuels and lubricants. Applicants should be aged 25 to 35 years and possess either an Engineering Degree or A.M.I.Mech.E. Salary according to age, qualifications and experience. Non-contributory pension fund. Assisted house purchase scheme. Removal expenses and settling-in allowance payable in certain cases. Luncheon club.—Write, quoting reference H.4155, to BOX 5306, c/o 191, Gresham House, E.C.2. E7279 A

BRITISH PETROLEUM COMPANY, LTD., has vacancies for MECHANICAL CONSTRUCTION ENGINEERS. Applicants, aged 25–35, must have at least H.N.C. in Mechanical Engineering and Corporate Membership of Institution of Mechanical Engineers is desirable, with experience on construction of civil and mechanical projects, preferably with contractors in a supervisory capacity. Should be accustomed to organising works sections and have some knowledge of contract documents and control of expenditure. Employment will be initially in the U.K. but successful candidates must be prepared to do terms of service abroad from time to time. Salary according to qualifications and experience. Non-contributory pension fund. Assisted house purchase scheme, removal expenses and settling-in allowance payable in certain cases. Luncheon club.—Write, giving full particulars, quoting H.3893, to BOX 5303, c/o 191, Gresham House, E.C.2. E7278 A

CIVIL ENGINEER required by the National Coal Board for their Central West Area with Headquarters in Glasgow. Salary range £1250–£2000 p.a. Candidates should be Associate Members of the Institution of Civil Engineers, or have similar qualifications, and have extensive experience in constructional work. The successful candidate will be responsible for supervising and for advising management on all Civil Engineering Projects taking place in the area.—Applications, stating age, education, qualifications, experience, present post and salary, to the Divisional Chief Staff Officer, National Coal Board, 3, Eglinton Crescent, Edinburgh, 12. E7267 A

CHEMICAL ENGINEER.—Senior man required by consulting organisation handling large petroleum/nuclear/chemical plants. He will be responsible for all aspects of chemical engineering design covering a wide range of unit operations. Experience of similar design work is essential, preferably in the field of petroleum processing. Pension/life assurance and personal accident schemes, house purchase assistance, luncheon vouchers.—Please send full details of qualifications, experience and salary envisaged, to Head Wrightson Processes, Ltd., 24/26, Baltic Street, E.C.1. E964 A

CHIEF DRAUGHTSMAN required by a progressive Company manufacturing ships winches, marine auxiliaries, haulage gears and other mechanical handling equipment. House available if required. Pension and life assurance scheme in operation. Reply in confidence giving full details of age,—experience, qualifications and salary required to: A. Barton (Engineers), Ltd., Providence Works, St. Helens Junction, Lancs. E7166 A

CIVIL ENGINEERING DESIGN/DRAUGHTSMEN.—Staff required by Westminster Consultants. General standard for the vacancies not less than second year H.N.C. Salary in relation to experience and technical education of the order of £700 to £1000. Two posts available, both long-term, with staff pensions, &c.—BOX No. E7251, "The Engineer." A

CONTRACTS ENGINEER experienced in boiler-house instrumentation required at Westminster offices to handle sales and technical correspondence orders and customer liaison. O.N.C. or H.N.C. level preferred. Starting salary according to age and experience.—Write in full to Sales Manager, Kelvin and Hughes (Industrial), Limited, 2, Caxton Street, London, S.W.1. E7157 A

DESIGN DRAUGHTSMEN

Imperial Smelting Corporation Limited, Avonmouth, Bristol, has vacancies for

MECHANICAL AND ELECTRICAL DRAUGHTSMEN

in the Drawing Offices of its Chief Engineer, and of a wholly-owned subsidiary, Imperial Smelting Processes, Ltd. A wide variety of work is offered and good promotion prospects exist for young men holding or prepared to obtain H.N.C. or equivalent. All appointments are permanent, with excellent conditions, including a non-contributory pension scheme and a generous free life assurance.—Write for application form to Personnel Manager, quoting Ref. DDN/TE. E7253 A

DESIGN ENGINEER OR SENIOR DESIGN DRAUGHTSMAN required by a leading manufacturer in South-East Essex for electro-mechanical instrument work.

At least five years' previous design experience in a similar or closely associated field is required.

Applicants should possess a good mechanical background, coupled with a sound electrical knowledge, and be of at least Higher National Certificate standard.

The initial salary will be in accordance with experience and qualifications within a scale which allows ample scope for designers capable of applying original ideas.

A contributory pension scheme is available and housing assistance may be given after a satisfactory probationary period.

Applications, which can be made in the strictest confidence, should give full particulars of qualifications, previous experience, age and salary required, and be addressed.—BOX No. E7237, "The Engineer." A

DESIGN ENGINEER required to take charge of Drawing-office in a Glass Works employing about 2000 people, manufacturing a large variety of pressed ware on modern automatic machines; the main products are used by the electrical and electronic industries. The work will be mainly concerned with mechanical engineering but experience in civil and electrical engineering would be an advantage. The successful applicant will be directly responsible to the Chief Engineer for the drawing-office work in development of existing machines, design of special purpose machines and layout of plant and services. A Degree in Engineering or equivalent qualification and considerable design experience are essential, but experience in the glass industry is not necessary. The position is progressive and pensionable and should provide an interesting career.—Replies, giving age, qualifications and experience, to the Personnel Officer (Staff), Pilkington Brothers Limited, St. Helens, Lancashire. E7207 A

DESIGNERS/DEVELOPMENT ENGINEERS/DRAUGHTSMEN required by DAVEY, PAXMAN & CO. LIMITED, Colchester. Interesting work on C.I. engines (traction, marine and commercial), Heat Transfer Apparatus, Boilers, Chemical Plant, Controls and Nuclear Projects. Superannuation scheme; excellent working conditions. Welfare, canteen and sports facilities. Healthy locality within easy reach of several East Coast resorts.—Apply in writing, stating age, experience, qualifications and present salary, to Personnel Manager. E7292 A

DEVELOPMENT ENGINEER required by Philblack Limited. This rapidly expanding company requires a Mechanical Engineer to assist in the design and improvement of plant. This position will satisfy an alert man capable of working on own initiative and keen to progress. Applicants should possess a B.Sc. Degree in Engineering, or Corporate Membership of a Major Institution, with suitable experience, not necessarily in plant construction or the carbon black industry. This is a permanent appointment, with a starting salary of at least £900 p.a., depending on experience and qualifications. Contributory pension scheme.—Apply, stating age, experience, full qualifications, to Works Engineer, Philblack Limited, Avonmouth Docks Estate, Avonmouth, Bristol. E1030 A

DRAUGHTSMAN and TECHNICAL ASSISTANT required immediately for work on 2-stroke Diesel Engines in S.E. England. Applicants should preferably be to H.N.C. standard and with diesel engine experience. The work is interesting and the prospects good. Contributory pension scheme.—Apply, with full particulars, to the Secretary, Tilling-Stevens, Ltd. (Rootes Group), Maidstone. E7205 A

DESIGNER-DRAUGHTSMEN AND DETAILERS, Mechanical, Structural and R.C. Design, required for work on Gas, Chemical, Blast Furnace and similar industrial plants. High salaries, modern semi-detached houses to let to senior, experienced men. Grants towards removal and living expenses until removal effected. Pension and insurance scheme, technical library, sports club.—Apply, Staff Personnel Manager, Ashmore, Benson, Pease and Co., Stockton-on-Tees. E7132 A

DESIGNER FOR NUCLEAR ENERGY PROJECT

RUSTON & HORNSBY, LTD., require a Designer for a project covering the combination of Gas Turbines and High Temperature Reactors for Power Production. Experience of Pressure Vessel, Heat Exchanger or Gas Turbine Design desirable. Minimum standard H.N.C. Post pensionable and progressive.—Applications, stating age, full qualifications and experience, to Manager, Industrial Relations Dept., Ruston and Hornsby, Ltd., Lincoln. E7269 A

DEVELOPMENT ENGINEER (MECHANICAL)

The development team at a meat products factory within the UNILEVER organisation require an additional professional engineer. The work will involve scope for original ideas in many varied projects.

Salary will be not less than £1100 per annum, according to age and experience, plus comprehensive superannuation and sickness benefit schemes.

Candidates should apply in writing to the Company Personnel Manager, T. Wall and Sons (Meat Products), Ltd., Atlas Road, Willesden, London, N.W.10, quoting reference No. 101. E7226 A

DRAUGHTSMAN required for air conditioning schemes involving refrigeration. Should have ability to assess capacities of refrigeration equipment and generally take charge of entire schemes with minimum supervision. Pension scheme, 5-day week, canteen.—Apply in writing to Personnel Manager (AJM), Birlec Limited, Tyburn Road, Birmingham, 24. E7249 A

DRAUGHTSMAN (Senior) having experience in machine design and works layouts. A knowledge of works building design desirable but not essential. Technical education to at least O.N.C. standard. DRAUGHTSMAN (Junior) for general engineering design or jig and tool design. Applicants are invited to submit full details of age, experience and salary required, to the Personnel Manager, Ferodo, Limited, Chapel-en-le-Frith, Via Stockport. E7159 A

DRAUGHTSMAN. Senior Mechanical Draughtsman preferably with design experience of medium size C.I. engines, urgently required by manufacturers of diesel engines. Five day week. Good salary offered. Canteen facilities.—Apply, Russell Newbery and Co., Ltd., Rainham Road South, Dagenham, Essex. E7161 A

DRAUGHTSMAN, SENIOR, experienced in coal handling, screening and general structural plant, required by group of South Coast companies with headquarters at Portsmouth. Staff pension scheme in operation. Apply, stating age, experience and salary required.—BOX No. E1024, "The Engineer." A

DRAUGHTSMAN urgently required for expanding Mechanical and Structural Engineering Company. Excellent prospects and congenial working conditions: holiday commitments honoured. Salary commensurate with ability.—Apply, William Jones, Ltd., Westmoor Street, Charlton, S.E.7. E7218 A

IMPORTANT

COVENTRY ENGINEERING FIRM

has vacancy for

DRAUGHTSMAN

with experience in preparing Tooling Layouts and Tool Drawings for Multi-Spindle Automatics. If necessary, a period of training could be arranged for applicant with reasonable qualifications.

Applications, with full particulars of age, experience and qualifications, to BOX No. E7265, "The Engineer." A

DRAUGHTSMEN required in the following categories; Senior and Junior Piping; Senior Civil; Mechanical, by engineers in City, engaged on Nuclear/Petroleum/Chemical plants. Salaries above average—5 day week—pension/life assurance and personal accident schemes—house purchase assistance—luncheon vouchers. H.N.C./O.N.C. desirable.—Write full particulars to Head Wrightson Processes, Ltd., 24/26, Baltic Street, E.C.1. E954 A

ELECTRICAL DRAUGHTSMEN able to work with minimum supervision, required by Power Station Contractors, for work on Nuclear Power development. 5-day week, superannuation scheme, good prospects and salary commensurate with qualifications and experience. Office situate South of Manchester. Write fully in first instance to Chief Draughtsman.—BOX No. E1032, "The Engineer." A

ENGINEERING INSURANCE COMPANY invites applications from Engineers not over 35 years of age who possess First Class M.O.T. Certificate (Steam) for position as ENGINEER SURVEYOR in London and surrounding districts. Progressive salary scale commences at £675 rising to £1000 per annum, plus expenses and allowances. Non-contributory pension scheme and other staff schemes. Apply in own handwriting.—BOX No. E7282, "The Engineer." A

Classified Advts. continued on page 6

SITUATIONS VACANT

ELECTRICAL ENGINEERING DRAUGHTSMEN of H.N.C. standard required. Applicants must be experienced in the preparation of schemes and estimates for illumination and electrical equipment of industrial buildings and H.V. and M.V. electrical distribution schemes. Experience in heavy D.C. distribution systems is desirable. Minimum starting salaries for draughtsmen of H.N.C. standard are from £747 p.a. at age 25. Conditions include a contributory superannuation fund, family education schemes, and some assistance with house purchase. Apply, stating age, qualifications and experience to the Works Personnel Officer, Pilkington Brothers, Limited, Cowley Hill Works, St. Helens, Lancashire. E7152 A

ELECTRONICS ENGINEER required by industrial instrument manufacturer for sales and quotation work on electronic products.—Write, stating age, experience and salary required, to Sales Manager, Kelvin and Hughes (Industrial), Limited, 2, Caxton Street, London, S.W.1. E7176 A

ENGINEERING ESTIMATORS required. Minimum qualifications O.N.C., with machine shop experience of jobbing and short-run production in medium/heavy range. Interesting work, integrated plant, own foundries and engineering shops, situated Monmouthshire. British subsidiary of American company manufacturing papermaking plant on a world scale. Excellent facilities, including superannuation scheme.—Full details, training, experience, qualifications and salary, to BLACK-CLAWSON INTERNATIONAL LTD., 18/19, Savile Row, London, W.1. E7286 A

ESTIMATOR for progressive position with prominent London firm of land and marine boiler engineers. Drawing-office experience essential; workshop experience an advantage. Attractive salary commensurate with experience and qualifications. Write fully, stating age, &c.—BOX No. E7093, "The Engineer." A

ESTIMATOR required by progressive Engineering Company. Must have experience in structural steelwork, light and heavy platework fabrications. Should be able to fix labour cost from detailed and schematic drawings; any knowledge of machining work an advantage. Apply with details of experience and salary required.—BOX No. E7274, "The Engineer." A

ESTIMATOR required for work on welded fabrication, pipework, &c. Ability to assess manufacturing times and build up complete detailed estimate. Applicants with works planning but not necessarily estimating experience considered. Pension scheme, 5-day week, canteen.—Apply in writing to Personnel Manager (AJM), Birlec Limited, Tyburn Road, Birmingham, 24. E7230 A

EXPERIENCED MECHANICAL ENGINEERING DRAUGHTSMAN required, not under 35 years of age, to take charge of a section of a drawing-office in North Lincs area, mainly concerned with development work on special-purpose machinery. Permanent appointment with pension fund. Good salary and prospects.—Applications, stating age, qualifications and experience, to BOX No. E7172, "The Engineer." A

FAR EAST Agent of mainly American firms requires :—
(a) AIR CONDITIONING AND REFRIGERATION ENGINEER.
(b) CRAWLER AND WHEEL TRACTOR AND PLANT ENGINEER.

Candidates for (a) must be able to take responsibility for Heading an Air Conditioning and Refrigeration Section, Design Application, Importing, Installation and Maintenance (of Freon piston and centrifugal compressor types).

Candidates for (b) must have wide experience of the service and maintenance of Crawler and Wheel Tractors, Shovels, Draglines, Road Building Equipment, &c.

Candidates for both vacancies must be of at least H.N.C. standard and preferably possess University Degrees.

Initial contract for 3 years with three months' paid leave. Passage paid. Housing provided. Salary in American dollars. No income tax. Interviews in London during mid-July. Applications in writing only, to :—
The Secretary,
The Professional Engineers Appointments Bureau,
9, Victoria Street, S.W.1,
stating age, practical experience, qualifications, &c. E1031 A

FORENSIC ENGINEERS invite applications from Engineering Graduates with good background and industrial experience for responsible and individualistic post. Age preferably 24 to 32 years.—BOX No. E4956, "The Engineer." A

FULLY QUALIFIED CHEMICAL AND MECHANICAL ENGINEERS

required to supervise implementation of contracts for export of large automated production plant. Responsibilities will include design co-ordination and engineering progress in U.K.; erection and installation overseas. A full period of training will be provided. Apply, giving full details of qualifications, experience and personal data.—BOX No. E7284, "The Engineer." A

INSTRUMENT ENGINEER.—Consulting organisation handling petroleum, chemical and nuclear plants, require a GRADUATE ENGINEER to assist in formulation of control schemes and to prepare specifications for relevant equipment. Some experience of the application of pneumatically operated instruments is essential. Pension/life assurance and personal accident schemes, house purchase assistance, luncheon vouchers.—Please send details of qualifications, experience and salary envisaged to Head Wrightson Processes, Ltd., 24/26, Baltic Street, London, E.C.1. E943 A

JUNIOR DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations, A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Apply by letter, giving details of technical education, to the Chief Draughtsman, Laporte Chemicals Limited, Clifton House, Euston Road, London, N.W.1. E6900 A

LADY TRACER required by consulting engineer's office, Westminster. Neatness and reasonable speed more important than civil engineering experience. Post not temporary; staff pensions and five-day week. Salary considered on basis of work and experience.—BOX No. E7250, "The Engineer." A

MANFIELD ENGINEERING DEVELOPMENT COMPANY, LTD.

Have vacancies for DRAUGHTSMEN n the following categories :—

1. Piping, Senior and Intermediate, experienced in oil refinery and chemical plant layout.
2. Plant Layout, Senior and Intermediate, for chemical, oil refinery and nuclear projects.
3. Structural and R.C., with first-class civil engineering experience.

Highest possible salaries will be paid to first-class men with the above experience.

Applications can be made in writing or by telephone to the above company at 54/56, Queen's Road, Peckham, London, S.E.15 (New Cross 6499). E1017 A

MECHANICAL DESIGNER sought by established manufacturers, in London, with world market for special-purpose precision machinery. Exceptional prospects for Qualified Mechanical Engineer having practical experience, aged 30–40, who is possessed of "the creative spark." Only applicant fertile in ideas, with original and inventive mind and receiving recognition in his present post on this account, need apply.—Write, in confidence, Personnel Manager, Molins Machine Co., Ltd., Evelyn Street, London, S.E.8. E7033 A

MECHANICAL ENGINEER ASSISTANT, age approximately 30/35, preferably with experience of planned maintenance of opencast Mining and Conveying Equipment and General Workshop practice, required for Mining Company in WEST AFRICA. Knowledge of work study, &c., essential. Commencing salary £1200 per annum but more would be paid for exceptional experience. Tours of duty approximately 15 months followed by liberal leave on full salary in U.K. Return passage paid. Free furnished quarters and medical attention. Marriage and Children Allowances. Contributory pension and life assurance and dependants income schemes.—Write, giving full particulars to Sierra Leone Development Co., Ltd., Dept. E6, City-Gate House, Finsbury Square, E.C.2. E7233 A

MECHANICAL ENGINEER required by Smiths Motor Accessories, Ltd. H.N.C. standard and at least 5 years' practical experience in light engineering, preferably instrument testing.—Apply to Mr. D. H. Squire, Cricklewood Works, N.W.2 (GLA 3333). E7290 A

METHODS ENGINEER required by large company producing Iron Castings for the Automobile Industry. Progressive organisation, operating three fully mechanised foundries, with a fourth in course of erection. Position is one of direct responsibility to the Works Director and requires knowledge of modern foundry practice, together with qualifications in Mechanical Engineering. Permanent staff position, pension scheme, canteen and social club facilities.

Applications, giving full personal details, &c., in writing, to :—
The Works Director,
THE MIDLAND MOTOR CYLINDER CO., LTD.,
Birmid Works,
Dartmouth Road,
Smethwick, 40, Staffs. E1026 A

MINING ENGINEER—Temporary—required for one or two tours of duty on interesting development work by Iron Ore Mining Company in SIERRA LEONE. Position would suit young Mining Graduate with some survey experience. Salary according to qualifications and experience. Tours of approximately 15 months, liberal leave on full salary U.K. Return passage paid. Initial kit allowance, camp equipment provided.—Write, giving full details, stating age, married or single, to SIERRA LEONE DEVELOPMENT Co., Ltd., Dept. ME.8, City-Gate House, Finsbury Square, E.C.2. E7232 A

PILKINGTON BROTHERS, LIMITED, who are the largest manufacturers of plate and sheet glass in the British Commonwealth and employ more than 20,000 persons, wish to appoint a HEAD of their TECHNICAL DEVELOPMENT DEPARTMENT. This is a new appointment, necessitated by the large number of development projects in hand. It is intended that the man selected should take charge of the development of new processes and the radical improvement of existing ones. There are ample technical resources available and the company spends large amounts on development work. Applicants must have a good Honours Degree in Engineering, Physics or Chemistry. They must also have a flair for development work, and the enthusiasm to see a job through. Applications will be welcomed from men aged preferably 35–45, who have done at least five years' successful and original development work in industry or at a university. The company is prepared to offer a service agreement at an attractive salary to the right man.—All applications will be treated confidentially and should be addressed to the Group Personnel Officer, Pilkington Brothers, Limited, The Glass Works, St. Helens, Lancashire. E7185 A

PLANNING METHODS ENGINEER.—The Parkinson Stove Co., Ltd., wishes to appoint a trained Engineer with up-to-date experience in autos, capstans, presses, welding, tooling and assembly flow-line techniques. This opportunity will appeal to a man of proved ability, energy and progressive ideas. Desirably he should also have served a recognised apprenticeship and possess H.N.C. (Prod. Eng.). The position is permanent and pensionable and carries a generous salary for the right type of man. Holiday arrangements already made will receive favourable consideration.—Apply in confidence, giving full details of age, education and experience, to Personnel Manager, Iron Lane, Stechford, Birmingham, 33. E7275 A

QUALIFIED METALLURGISTS AND MECHANICAL ENGINEERS, age 25/30 approx. Preferably with research or industrial experience, required for expanding light metal industry in Sydney, Australia. Passages paid. General Manager now in U.K. and can grant interviews.—Apply, General Manager, Australian Aluminium Co. (Pty.), Ltd., c/o British Aluminium Co., Ltd., Norfolk House, St. James's Square, London, S.W.1. E7209 A

REINFORCED CONCRETE DESIGNERS AND DESIGNER-DRAUGHTSMEN required, to work in London office on the nuclear power project at Berkeley.—Please write, giving details of previous experience, to BOX No. 715, Glovers, 351, Oxford Street, London, W.1. E955 A

RESIDENT ENGINEER required for mechanical and plant erection work on new Oil Refinery and Chemical Plant Construction. Should be experienced in use of heavy lifting equipment, pipe lines, &c., and control of labour. Commencing salary up to £2000 p.a., according to experience and qualifications. Please write in confidence, giving full particulars of past employers and contracts carried out.—BOX No. E7208, "The Engineer." A

RESIN/GLASS DEVELOPMENT PHYSICIST OR MECHANICAL ENGINEER.—Graduate Physicists or Mechanical Engineers, who are interested in the field of fibreglass reinforced plastics, are invited to apply for a vacancy in the Development Department of Fibreglass Limited, St. Helens. The work will be primarily on the testing of mechanical properties of materials, and it would be an advantage if the applicant were conversant with techniques and equipment for specialised tests, including creep and fatigue.—Applicants, who should preferably be not more than 35 years of age, are invited to send details of their qualifications and experience to the Personnel Liaison Officer, Pilkington Brothers, Limited, St. Helens, Lancashire, of whom Fibreglass Limited is a subsidiary company. E7258 A

SALES REPRESENTATIVE required for Southern Counties. Applicants must have thorough knowledge of modern mechanical handling equipment for sand, gravel and general quarrying plant.—Apply, stating experience and salary required, to Niagara Screens (Great Britain), Ltd., Clay Hill, Enfield, Middlesex. E1011 A

SENIOR DESIGNER DRAUGHTSMAN, with flair for design work, required by small/medium size engineering firm in South West London building papermaking machinery. Previous experience in this field is not essential, but applicants should have qualifications at least equal to Higher National Certificate standard. The work is interesting with opportunities for studying equipment in the field. The prospects are good. Pension scheme.—BOX No. E7273, "The Engineer." A

SENIOR DRAUGHTSMAN required for work on pressure vessels, valves, pipework layouts. Knowledge of established manufacturing codes an advantage. Pension scheme, 5-day week, canteen.—Apply in writing to Personnel Manager (AJM), Birlec Limited, Tyburn Road, Birmingham, 24. E7231 A

SMITHS MOTOR ACCESSORIES, LTD.,
require :

SENIOR DESIGN DRAUGHTSMAN, with experience of instruments or light engineering. Minimum qualifications, 3 years' design experience, O.N.C. standard. Monthly status for right man.

SENIOR DRAUGHTSMAN, for Production Drawing-Office, with experience of instruments or small mechanisms, at least O.N.C. standard. Knowledge of press work an advantage.

WORK STUDY ENGINEERS, fully qualified.

SENIOR TRACER, woman, preferably with experience of engineering drawings.

PLANT LAYOUT DRAUGHTSMAN, O.N.C. or equivalent, with experience of minor building alterations. Layout of machine tools.

METHODS ENGINEER, sound mechanical background with some knowledge of assembly procedure and layout.

Apply to Mr. D. H. Squire, Cricklewood Works, N.W.2 (GLA 3333). E7294 A

TECHNICAL CLERK required in Diesel Engine Company, capable of handling technical correspondence and to act as Liaison with Engineering Departments.—Apply, with full particulars, to the Secretary, Tilling-Stevens, Ltd. (Rootes Group), Maidstone. E7206 A

TECHNICAL SALES REPRESENTATIVE.—Midland engineering company, specialising in all types of transmission gearing, requires two salaried Technical Representatives, one for North London area and one for South London area. Residence within specified area preferred. Car provided. Applicants (who preferably should be on the telephone and have garage accommodation) should send fullest details of age, experience, salary at present receiving and particulars of existing connections.—BOX No. E7276, "The Engineer." A

TECHNICAL SALES REPRESENTATIVE required to take over and extend existing connections among steel works, engineering works and scrap metal merchants for hydraulic plant sales. Engineering background and selling experience essential. Only energetic men of highest integrity, capable of working on own initiative need apply. Resident in or near London preferred. Good salary, pension scheme, car and expenses. Write, giving full details of past experience, age, and salary required.—BOX No. E1035, "The Engineer." A

TOOL ROOM SUPERINTENDENT required by a firm of medium/heavy engineers on batch production, East Midlands. Thirty-four toolmakers employed. Candidates should be between 35 and 45, should have served their time as toolmakers, followed by tool room service. Experience in the handling of men and in the drawing-office would be an advantage. Assistance given with housing. Excellent local educational facilities.—BOX No. E7247, "The Engineer." A

THE EDISON SWAN ELECTRIC CO., LTD.
(An A.E.I. Company),
require at Brimsdown,
a
LIAISON ENGINEER
to co-ordinate flow of technical and production information between main development departments and overseas factories. Background of drawing-office or similar experience desirable, preferably on valves, cathode ray tubes or electronic equipment. Some technical education and ability to write clear letters and reports essential.—Apply, Personnel Superintendent, Ediswan, Cosmos Works, Brimsdown, Enfield, Middlesex. E7236 A

THE INTERNATIONAL SYNTHETIC RUBBER COMPANY LIMITED

ELECTRICAL FOREMAN

The International Synthetic Rubber Company Limited, at Hythe, Hampshire, will shortly engage an Electrical Foreman who will be responsible to the Works Electrical Engineer for the control of electrical trades in the Maintenance Department. Applicants should have served a recognised apprenticeship and be experienced in the maintenance of H.V. and L.V. distribution networks, large A.C. machines and Motor Control Gear. A knowledge of Flame Proof Equipment and Planned Maintenance Systems would also be of advantage.

This is a staff appointment with excellent conditions of employment, including superannuation.—Reply, giving full details, to :
The Personnel Manager,
The International Synthetic Rubber Co., Ltd.,
Hythe,
Hants. E7203 A

THE SUPERHEATER COMPANY, LIMITED,
POWER PLANT DIVISION,
53, Haymarket, London, S.W.1,
requires ENGINEERS having Degree, Higher National Certificate or equivalent, for the engineering and commercial departments in London. Suitable men are needed for the technical, estimating and purchasing departments and for senior positions in the drawing-office. Previous experience in steam power plant, whilst an advantage is not essential.

All the above positions are permanent and pensionable and afford excellent opportunities for keen and energetic men.

Applications are invited in the first instance to the Secretary at the above address, giving full details of qualifications and experience. E7277 A

VALUER OF PLANT AND MACHINERY required, experienced, with up-to-date knowledge of general machinery, &c.—Full particulars, in confidence, to Leopold Farmer and Sons, Industrial Auctioneers and Valuers, 46, Gresham Street, London, E.C.2. E7283 A

VICKERS-ARMSTRONGS (ENGINEERS), LIMITED.

MECHANICAL ENGINEERS.

Applications are invited from MECHANICAL ENGINEERS with ROLLING MILL and/or EXTRUSION SHOP experience, for an opening to be available in the near future.

Preference will be given to Graduate or Associate Members of the Institution of Mechanical Engineers.

Duties will include supervision of mechanical plant in rolling mills, extrusion shops, melting shops and foundry (brass), together with advising and planning of improvements and developments.

Please write, giving details of age, education, experience, salary, &c., to :—
Personnel Officer,
VICKERS-ARMSTRONGS (ENGINEERS), LIMITED,
Elswick Works,
Newcastle upon Tyne, 4. E7254 A

WORCESTER—JIG AND TOOL DRAUGHTSMAN required for engineering works engaged on mechanical handling. Housing available shortly. Five-day week, canteen, pension scheme.—Apply, with full details of age, experience, qualifications to The Mining Engineering Company, Ltd., Worcester. E1006 A

WORTHING VINERIES, Poling, Sussex, requires first-class, all-round ENGINEER FITTER, fully experienced in the running and all-round maintenance of modern oil-fired boilers, and all ancillary plant, including direct responsibility for present operating staff. Service accommodation provided. Salary according to experience. Please write, giving full details of training, experience and present position held, enclosing copies of two recent testimonials. E7291 A

YOUNG ENGINEERS (25–30) required for Chief Mechanical Engineer's office. Candidates must have sound practical workshop and drawing-office experience, and a knowledge of installation and services. The position requires a man of good technical education, capable of adapting himself to changing demands in a variety of engineering projects. Conditions of service include five-day week, profit-sharing bonus, pension scheme and free lunches.—Write giving details of age, education and experience, &c., quoting the reference "Mechanical Engineer," to the Secretary, Johnson, Matthey and Co., Limited, 78, Hatton Garden, London, E.C.1. E7054 A

SITUATIONS VACANT

Canada : Required by expanding Furnace and Steelworks Engineering Company in Ontario, the following staff :

LAYOUT DRAUGHTSMEN.
DESIGN DRAUGHTSMEN.
GROUP LEADER DRAUGHTSMEN.
SALES ENGINEERS.
COMBUSTION ENGINEER.

Applicants must be experienced in either or all of the following types of work :

(a) Heavy furnaces—gas, oil or electric.
(b) Soaking Pits.
(c) Aluminium melting and reheating furnaces.
(d) Continuous or box annealing furnaces.
(e) Open hearth and steel plant layouts.

Apply, stating type of furnace or other experience, age, education, telephone number, and when available. Ample salaries will be paid to suitably experienced men. Our General Manager will be in the U.K. to interview suitable applicants around the beginning of July, 1957.

Reply to BOX No. E1025, " The Engineer." A

SITUATIONS VACANT

THE HARLAND ENGINEERING COMPANY LIMITED, ALLOA

have a vacancy for a

SENIOR DESIGN DRAUGHTSMAN

thoroughly experienced in

HYDRAULIC TURBINES

and ancillary equipment.

Salary in region of £1000 p.a. ; attractive working conditions in new office block ; good pension scheme.

Write in confidence, stating qualifications and experience, to :

CHIEF DRAUGHTSMAN,
B.E.P. WORKS, ALLOA, SCOTLAND.

E7181 A

SITUATIONS VACANT

SENIOR ENGINEERS

with a good Degree in Mechanical Engineering and experience of high temperature/pressure thermodynamic design are required for the Steam Turbine Design Department at " English Electric," Rugby.

The positions offer good opportunities in new fields of development and the Company can give tenancies of Company houses to suitable married men.

Write in confidence, giving details of training and experience, to Dept. C.P.S., Marconi House, 336/7, Strand, W.C.2, quoting reference E1107M. E7241 A

SITUATIONS VACANT

GENERAL WORKS MANAGER

Exceptional opportunity for

QUALIFIED MECHANICAL ENGINEER

to take charge of design, production and general administration of medium-size Engineering Works in the North. Must be first-class organiser and experienced in light and medium heavy engineering. Attractive salary to suitable man who can take charge immediately of growing organisation.

Pension scheme, housing assistance.

Full particulars of age, qualifications, experience, &c.—BOX No. E7240, " The Engineer." A

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JIG & TOOL

Applications are invited from men with good experience on jig and tool design related to a wide range of machining and assembly operations.

This is a senior appointment in an interesting field of work, and a technical qualification to Higher National Certificate level is desirable, although not essential.

Excellent conditions of service are offered including

ASSISTANCE WITH HOUSING

Applications, in writing or by telephone, giving full details of age, experience, qualifications and salary required should be made to :—

Staff Officer,

British Oxygen Engineering Ltd
Angel Road · Edmonton
LONDON N.18

E81 A

Management Selection Limited

have been retained to advise on the appointment of a

WORKS GENERAL MANAGER

for the Scottish factory of the long established Company of R. & A. Main Limited who occupy a leading position in the domestic appliance industry. The Company's turnover approximates to several million per annum and there are more than 500 employees in the Scottish factory.

The Board wish to appoint a man capable of managing the factory with little reference to Head Office and have asked us to find a man suitable to become a director at a later stage.

Qualifications required are preferably a university degree in engineering or equivalent with a solid foundation of practical experience. Candidates must show a record of successful management of a factory employing more than 100 people. Experience of press shop work is necessary, also a grasp of modern methods of production engineering, cost control and quality control. Age preferred about 40.

Salary up to £3000 per annum. Car provided. Pension scheme. Housing can be discussed specially.

Please send brief details in confidence, quoting reference G.450, to E. P. Kelsall, Management Selection Limited, 17, Stratton Street, London, W.1. No information will be disclosed to our clients until candidates have given permission after personal discussion. E7182 A

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ICI

MECHANICAL ENGINEERING DRAUGHTSMEN

IMPERIAL CHEMICAL INDUSTRIES LIMITED,
BILLINGHAM DIVISION

Draughtsmen are needed to join a team of Research Engineers and Chemists developing laboratory equipment, semi-technical and pilot chemical plant.

The work of the Research Department covers a wide field of new and unusual work providing scope for designers with imagination and initiative working in close collaboration with the laboratory workshops.

All employees enjoy a flexible salary scheme and join the Pension Fund and the Profit-Sharing Scheme. Married men are assisted with removal expenses. Applicants should hold the Higher National Certificate or its equivalent or have suitable specialised experience. To follow this up, write to the Staff Manager, Imperial Chemical Industries, Limited, Billingham Division, Billingham, Co. Durham, quoting reference W/Q/1. E7116 A

Classified Advts. continued on page 8

SITUATIONS VACANT

G.E.C.

SENIOR MECHANICAL ENGINEERS

THE RESEARCH LABORATORIES OF THE

GENERAL ELECTRIC CO. LTD.,

NORTH WEMBLEY, MIDDLESEX

employ nearly 3,000 staff covering major fields in Engineering and the Physical Sciences.

The work of SENIOR MECHANICAL ENGINEERS serves the whole range of these activities so that both the professional experience and the opportunities offered are exceptional.

New posts are being created for several men who can translate experimental equipment into fully designed machines suitable for large-scale automatic production. A knowledge of pneumatics, hydraulics and electro-mechanical devices is essential. Minimum qualifications would be an Engineering Degree or H.N.C. with not less than five years' design experience.

Applications will be treated in full confidence and should be addressed to

THE STAFF MANAGER, (Ref. RLO/136),

giving particulars of experience, qualifications and age.

E7155 A

A CAREER IN SOUTH AFRICA

AFRICAN EXPLOSIVES AND CHEMICAL INDUSTRIES LTD.

has vacancies for

(*a*) SENIOR ENGINEERS (Mechanical or Electrical)

Minimum qualifications : B.Sc. (Engineering) and/or Corporate Membership of either of the Engineering Institutions.

(*b*) SENIOR ENGINEER (Work Study)

Minimum qualifications as (a) above, and previous experience in Work Study.

Total emoluments, which include a cost-of-living allowance and annual bonus, will lie within the range of £1750 to £3250 for the (a) posts and £1750 to £2250 for the (b) post.

Initial placement will depend upon qualifications, experience and personal qualities.

Conditions of service include :

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(b)) Guaranteed accommodation for renting.
(c) Membership of Pension Fund or Provident Fund and Medical Aid Society.
(d) Leave facilities which make provision for long leave at intervals.

Further information and application forms can be obtained from Mr. H. W. Ahrens, AFRICAN EXPLOSIVES AND CHEMICAL INDUSTRIES, LTD., Imperial Chemical House, Millbank, London, S.W.1. E7126 A

SITUATIONS VACANT

ENGINEERING IN THE CHEMICAL INDUSTRY?

Why s the Chemical Industry of interest to the Engineer ? Firstly, because it uses a wider selection of engineering plant and equipment than any other branch of industry ; secondly, because the problems which it has to tackle are such that their solution depends as much on the Engineer as on the Chemist. The industry is expanding rapidly and at

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over 4700 men are working on the design and construction of the largest single project in Britain's chemical history. Wilton Works is a manufacturing centre, with its own power station, where any Division of I.C.I. can build and operate production units. Twenty-one plants are in operation to-day and included in these are " Perspex," " Terylene " and Titanium. The number of

MECHANICAL, ELECTRICAL AND INSTRUMENTATION ENGINEERS

required for design, construction, operation and work study is steadily increasing as the Works continue to grow.

Salaries depend on ability and experience and are reviewed annually after appointment. Promotion is by merit alone and individuals are considered at regular intervals. Help will be given with housing and removing. The design offices are pleasantly situated in the parklands of Wilton Castle, which lies at the foot of the Cleveland Hills. Suitable applicants, who should possess an Honours Degree, will be invited for interview at the Company's expense.—Please write to the Staff Manager, Imperial Chemical Industries, Limited, Wilton Works, Middlesbrough, Yorkshire, quoting 396/4. E7023 A

SHELL

invites CHEMISTS CHEMICAL ENGINEERS PHYSICISTS MECHANICAL ENGINEERS

to join their chemical plants and oil refineries in the United Kingdom.

Seldom in the industrial field has expansion been more marked in the last decade than in the petroleum chemical industry, and the future in this field is unlimited.

Both the petroleum chemical and the oil refining industries offer well paid careers of absorbing interest, and to those with the required technical qualifications the way is open to the highest posts of Management.

Candidates should possess a University Honours Degree or appropriate professional qualifications. Commencing salary according to age, qualifications and experience. Chemical and mechanical engineer graduates are offered a two-year post-graduate apprenticeship for which National Service deferment is granted. Contributory Pension Scheme. Educational Endowment Scheme. Facilities available for assistance in house purchase. Candidates invited for interview will be paid reasonable travelling expenses.

If you are interested in these vacancies and would like to have an application form and/or copy of appropriate careers booklet, please write, stating profession, to Staff Department H2, Shell Refining Company Limited, P.O. Box 83, London E.1.

THE SHELL PETROLEUM COMPANY LIMITED
SHELL CHEMICAL COMPANY LIMITED
SHELL REFINING COMPANY LIMITED

E78A

SITUATIONS VACANT

DAVID ROWAN & CO. LTD.

Marine Engineers and Boilermakers.
231, ELLIOT STREET,
GLASGOW, C.3.

Require a fully qualified

MACHINE SHOP SUPERINTENDENT

to take full charge under the Works Manager of the various Machine Shops producing parts for Diesel Marine Engines and Steam Turbines. Please submit reference and state age, experience and present salary.

ALSO

PLANT DRAUGHTSMAN

with knowledge of Works Building Construction, Services and Repairs also Machine Tool and Plant Layout. Please submit reference and state age, experience and present salary E7139 A

SITUATIONS WANTED

ENGINEER, Structural and Mechanical, seeks Outside Appointment. Used direction of labour and site control. Capable designer, M.Inst.W. and M.Inst.B.E. and H.N.C. Experienced D.O. Write-stating post offered and terms.—BOX No. E1028, "The Engineer." B

TECHNICAL REPRESENTATIVE / SALES, M.I.Mech.E., W.R. Yorks. Competent handle top-level business, mechanical hydraulic, capital or consumer. First-class opportunity for representation of the highest integrity.—BOX No. E1008, "The Engineer." B

YOUNG ENGINEER, 8 years executive, with unique commercial and consultant experience at board level, offers services to enterprising company. Willing to travel. Please write.—BOX No. E1029, "The Engineer." B

AGENCIES

TECHNICAL SALES ORGANISATION with excellent connections, Lancs and Yorks, require Agencies Allied to Steam/Electrical/Aircraft Industries.—Write, 2060, Wm. Porteous and Co., Glasgow. E7244 D

FOR HIRE

LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone SLOane 5259). E112 E

DRAWING & DESIGN SERVICE

LONDON FIRM OF ENGINEERS, with experienced and well-qualified Heating and Ventilating department, require Design Work for Heating, Ventilating, Air Conditioning and Oil firing Installations. Specifications prepared and site supervision undertaken if required.—BOX No. E7060, "The Engineer." S

BUSINESSES and PREMISES

FACTORY, WAREHOUSE, GARAGE, East London, 10,000 square feet, 8000 covered. Two entrances, single storey, concrete floor, all services. To Let on Lease, 14-21 years.—BOX No. E1033, "The Engineer." L

PATENTS

THE PROPRIETORS of British Patent No. 705,363, for "IMPROVEMENTS IN OR RELATING TO GAS TURBINE PLANTS," desire to enter into negotiations with a firm or firms for the Sale of the Patent or for the grant of Licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E7228 H

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process; sample castings treated; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E575 MW

KELLERING and Profile Milling in all metals. Send us your die blocks to copy from wood or plaster masters, Up to 5ft. by 8ft. max. size. We are die copiers to the trade.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Tel.: Knottingley 2743/4). E948 MW

PRECISION ENGINEERING COMPANY, Est. 50 years (A.I.D. and A.R.B. approved), with comprehensive plant situated 40 miles S.W. London, will shortly have spacer capacity. Interested in sub-contract work or manufacture of new lines or components or assemblies to be manufactured under licence from abroad.—Pilgrims Way Motor Co., Ltd., Farnham, Surrey. E1022 MW

PRECISION ENGINEERS.—Personal service for prototypes, small quantity machined parts and equipments. Design and development undertaken. A.I.D. Approved.—Bowyer, Smyth and Partners, Ltd., Vineyard Walk, Clerkenwell, E.C.1 ('Phone, TERminus 5113-4). E650 MW

SUB-CONTRACTING

LIMITED CAPACITY AVAILABLE

TURNING. Surfacing and Boring, 48in. swing. Between centres, 24in. swing by 7ft. 6in. Capstan, 2½in. bar.
MILLING. Horizontal, Vertical and Universal.
DRILLING. Pillar and Radial, 4ft.
General Fitting, Fabrication, Profiling, Welding, Sub and Complete assemblies.

NUFLOOR LIMITED
Engineering Division,
BASILDON, ESSEX.
Telephone: Basildon 20201. E963 MW

ACCURATE MACHINING

also on Models and Prototypes, &c.

MILLING TURNING
JIB BORING PLANING
PRESS TOOLS, JIGS AND FIXTURES
HORIZONTAL BORING

GIVE US YOUR DIFFICULT JOBS

LANDEN (ENGINEERS) LTD.
1A, AUBERT PARK, LONDON, N.5.
CANonbury 1075. E871 MW

OLD-ESTABLISHED and well-equipped Designers and Manufacturers of Industrial and Marine Steam Engines and Special Purpose Machinery for the Plastic and Food Producing Industries have capacity available for similar or other manufactures. Technical and manufacturing staff available. Would consider manufacture under licence if desired.—W. Sisson and Co., Ltd., Sisson Road, Gloucester. E1003 MW

CASTINGS

Midlands Foundry has immediate capacity for:

All types of jobbing and repetition grey iron castings up to 10 tons in weight.

Non-ferrous castings up to 2 cwts. in weight.

All enquiries will be given immediate attention.

BOX No. E7242, "The Engineer." MW

MISCELLANEOUS

LARGE COMPANY in Coventry has for disposal quantities of Bright-Drawn Mild Steels, Alloy Steels, Case Hardening Steels, P.B. Cored Stick, Brass Bar, Mild Steel Tubing. Stock list will be made available.—BOX No. E7180, "The Engineer." I

TECHNICAL ILLUSTRATIONS prepared from engineers' drawings. Scale isometric or perspective projections, exploded or cut-away. For spare part lists, production aids or advertising.—BOX No. E1034, "The Engineer." I

MACHINERY Etc. WANTED

JOG BORER and No. 2 MILLING MACHINES. Urgent.—BOX No. E7223, "The Engineer." F

PLANT WANTED.—Plate Shearing Machine, to cut ¾in. thick by 3ft. wide.—Full details to United Wire Works, Ltd., Granton, Edinburgh. E7224 F

READY MONEY for Redundant Electrical Equipment. Complete works bought outright for expert and rapid dismantling.—F. C. Larkinson, Ltd. (Est. 1880), Hitchin Street, Biggleswade, Beds (Tel. 2391); 12 branches throughout the country. E959 F

WANTED.—2-3 tons Electric Overhead Travelling Crane, 42ft. span, 400 volts, 3/50, cab-operated.—BOX No. E7246, "The Engineer." F

WANTED, Machines of all Types.
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Moseley Road, Birmingham, 12. VIC. 1278, 1279, 1270 0856. E123 F

FOR SALE

LOCOMOTIVES. 2 Hudswell Clarke, Saddle Tank, standard gauge, 15in. by 22in. cylinders, 180 lb. pressure. For further particulars apply to Appleby-Frodingham Steel Co. (reference P/B), Scunthorpe, Lincs. E7105 G

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft. and 30ft. wide huts; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent (Tel., Bexleyheath 305). E681 G

FOR SALE, Open Top Cast Iron Sectional Tank, 6100 cubic feet capacity.—BOX No. E1010, "The Engineer." G

FOR SALE

BY ORDER OF THE MINISTER OF SUPPLY

SALE BY TENDER

SURPLUS GOVERNMENT MACHINE TOOLS OF BRITISH AND CONTINENTAL MANUFACTURE

The Minister of Supply offers FOR SALE BY TENDER the following MACHINE TOOLS, both Used and Unused:—

SOMUA 32in. by 360in. CENTRE LATHES; PITTLER 32mm. and 50mm. CAPSTAN LATHES. DEUTSCHLAND SHAPING MACHINE, 32in. stroke; NASSOVIA Model V.11 DIE SINKER. 6in. and 6½in. ACME GRIDLEY 8-Spindle AUTOMATIC LATHES; CINCINNATI 3/36 HYDROMILLS.

SCRIVENER 2 DP. CENTRELESS GRINDERS; ORCUTT 20in. SPLINE GRINDER; ORCUTT 24in. INTERNAL GRINDER; SUNDSTRAND RIGID MILL.

Also: Hahn and Kolb 1in. Capstan Lathes; Hasse and Wrede Combination Turret Lathes, 19½in. and 26½in. swing; Scheu PR 80, 29in. swing, Turret Lathes; Pacific PTR. 32in. High-speed Turret Lathes; Foster Fastermatic Hydraulic Turret Lathes; Bertram Centre Lathe, 16in. swing by 28ft. B.C.; Heyligenstaedt Type 3 PB. S. and B. Lathe; Wifag R.B.51, 2in. Capstan Lathe.

Olivetti Plain Grinders; Mopco Semi-Universal Grinders; Kolb Spline Grinder; Rowland Duplex Grinders.

G.S.P. Radial Drills; Kolb K.S.T. 65 Pillar Drills.

Olivetti F.P.2 Manufacturing Millers; Pegard M.P.H. Manufacturing Millers; Cuttat Plain Hypermill Millers; Sant Andrea Vertical Millers; Dutch A.1. Horizontal Miller; Becker Special Purpose Millers.

Ludwigsburger Horizontal Borers, and Grinding nd Lapping Machines.

Dutrannoit Slotters; Wickman Moulton 1.B. Thread Miller; Bronx Bar Reeling Machine; Buck and Hickman Chamfering Machine; Robertson Forming Machine, Seven Stand Section, &c.

Applications for Tender forms should be made as soon as possible to the Director of Disposals 2.B., Room 621, Ministry of Supply, First Avenue House, High Holborn, W.C.1 (telephone: Chancery 6888, extension 1294).

Tender forms will contain descriptions of the machine tools, locations, and the conditions of sale under which they are offered.

Offers are invited for single machines.

The final date for the receipt of Tenders will be the 18th July, 1957. E7133

MINISTRY OF COMMERCE FOR NORTHERN IRELAND

BORING AND ANCILLARY EQUIPMENT

The Ministry of Commerce for Northern Ireland has in its possession a quantity of used BORING and ANCILLARY EQUIPMENT which it is offering for sale. The equipment consists mainly of various items of machinery, drill rods and casings, and in addition there is included a quantity of Miscellaneous Boring Equipment, Tools and Engine Spares. The main items are as follows:—

MACHINERY

1 No. "Climax" Generator powered by 14 h.p. petrol engine manufactured in Iowa, U.S.A., and ex-U.S.A. Army equipment.

1 No. "Murex" Generator powered by 12 h.p. Morris engine.

1 No. "Small Power Dynamo and Motor Co. Limited" 1kVA Generator powered by Villiers engine.

1 No. 2in. "Warsop" Pump powered by J.A.P. engine.

1 No. "Longyear" Drilling Unit powered by "Hercules" diesel engine.

1 No. "Gardner Denver" Pump powered by "Caterpillar" D.4400 diesel engine.

1 No. 3in. by 5in. "Gardner Denver" Pump powered by "Petter" diesel engine.

BORING EQUIPMENT

2 No. 72ft. high by 20ft. base Steel Derricks—dismantled. About 970 Drill Rods, 10ft. to 20ft. length, 1¼in. to 2¾in. diameter, and 410 Casings, 10ft. to 20ft. length, 2in. to 6¼in. diameter.

The equipment is stored at the Ministry of Labour and National Insurance Training Centre, "Felden," Whitehouse, Co. Antrim, and at Ministry of Finance Stores, Ridgeway Street, Belfast.

CONDITIONS OF SALE

Offers for the Purchase of any or all of the equipment should be made in writing to the Secretary, Ministry of Commerce, Chichester House, Chichester Street, Belfast, on or before 3 p.m. on 26th July, 1957, and must be made on the following conditions:

(1) The Ministry accepts no responsibility for the condition, completeness or state of repair of any of the items.

(2) The offer(s) must be for the purchase of the item(s) as they lie and must include for their complete removal from the storage site within 7 days of receipt of notification of the acceptance of an offer.

(3) The Ministry does not bind itself to accept the highest or any offer.

(4) Payment must be made before the removal of the items. E7263

TURNING MACHINES

FARMER NORTON 4in. CENTRELESS BAR TURNING MACHINES. M.D.400/3/50. With various cutter heads, in and out feed bar carriers, &c.

H. BELL (MACHINE TOOLS), LTD.,
Walter Street, Leeds, 4.
Tel.: 63-7398. E185 G

SECTIONAL TOWER TANKS

One Sectional 19,000-gallon, 24ft. by 16ft. by 8ft. deep, with cover and 20ft. tower.
One Sectional 12,800-gallon, 16ft. by 16ft. by 8ft., with cover and 30ft. tower.

WILLIAM R. SELWOOD, LIMITED
CHANDLER'S FORD, HANTS. 'Phone 2275. E7195 G

FOR SALE

DIMCO

A SELECTION OF MACHINE TOOLS FROM STOCK

MILLERS.

CINCINNATI 2M Vertical Miller. Table 33in. by 11in. Working surface 49in. by 10½in. Speeds 31-660 r.p.m. Power feeds and rapid traverses in all directions.

CINCINNATI 52in. by 12in. Dial Type Plain Miller, No. 2. Medium speed. Power feeds and rapid traverses in all directions.

KENDALL & GENT 25RVM Vertical Miller with combined rectangular and circular table. Working surface of table 48in. by 20in. Spindle speeds 25-375 r.p.m. Circular table diameter 22in.

GRINDERS.

KEIGHLEY 12in. by 36in. Hydraulic Universal Grinder. Infinitely variable speeds to table. Machine new 1953. Complete with standard equipment, including chucks, steadies, two interna spindles, &c.

BORERS.

KEARNS No. 1 Patent Head Horizontal Boring, Surfacing and Facing Machine. Spindle diameter 2½in. Maximum diameter facing 24in. Facing head to outer stay 48in. Complete with equipment. Approx. 1941.

PLANERS.

CHURCHILL-REDMAN 13in. All-geared Gap Bed Heavy Duty S.S. and S.C. Lathe, Model N.M. 16 spindle speeds from 8-253 r.p.m. Swings in gap 50in. by 20in. Distance between centres 69in. Hollow spindle 5½in. Considerable equipment.

MISCELLANEOUS.

EDGWICK 50in. Broaching Machine. Maximum pull 20 tons.

DIMCO (GT. BRITAIN) LTD.
415-417, OXFORD STREET,
LONDON, W.1.
Tel.: Mayfair 1585. E961 G

600

ROLLING MILLS

Motor-driven Hot Rolling Mill by ROBERTSON, type R, rolls 24in. diam. by 36in. face, speed 150ft. per min. Driven by 250 h.p. auto.-synch. motor, 500 r.p.m. Tot. enc. roll gears and enclosed reduction gearbox. Force feed lubrication, water cooled bearings, rolls arranged with motor-driven adjustment to nip. Previously used for hot brass ingots 12in. by 2in. by 3ft. 6in. long. Approx. weight 80 tons. Complete with spare rolls. Available for immediate inspection.

One Motor-driven Cold Rolling Mill by ROBERTSON, type R. Rolls 24in. diam. by 36in. face, speed 70ft. per min. Driven by 200 h.p. auto.-synch. motor, 500 r.p.m., tot. enc. roll gears and enclosed reduction gearbox. Force feed lubrication, water cooled bearings, rolls arranged for hand-operated nip. Previously used for brass strip 12in. by 1in. thick by 7ft. long. Approx. weight 90 tons. Complete with spare rolls. Available for immediate inspection.

GEORGE COHEN,
SONS AND CO. LTD.
WOOD LANE, LONDON, W.12.
Tel.: Shepherds Bush 2070; and
STANNINGLEY, NR. LEEDS.
Tel.: Pudsey 2241. E206 G

FRED WATKINS (BOILERS), LTD.

RECONDITIONED MACHINERY FOR SALE

STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic, 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p.; 300 reconditioned Vertical Crosstube, all sizes.

AIR COMPRESSORS.—Broomwade 510 cu. ft.; Tilghman 365 cu. ft.; Ingersoll 300 cu. ft.; Broomwade 300, 200 and 130 cu. ft.; all motorised.

200 AIR RECEIVERS, stocked up to 9ft. dia. 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

CRANES.—8½-ton Ransomes Diesel Electric, 1952; 6-ton Coles Diesel-Electric, 1948; 4-ton Jones KL44 Mobile Diesel; 4-ton Coles Diesel-Electric; 3-ton Jones Diesel "Super 40" (3); Neals 2-ton Diesel, 20ft. jibs (10); 5-ton Butters, 90ft. jib; 5-ton Wilson, 70ft. jib, all 400/3/50; Steam Loco Type, 8-ton Wilson, 35ft. jib; 5-ton Smith, 50ft. jib (2); 5-ton Cowans Sheldon, 50ft. jib, 1940; E.O.T., 40-ton Butterley, 42ft. 3in. span; 20-ton Clyde "Goliath," 40ft. track; 5-ton Clyde, 34ft. span; 2-ton Smith, 34ft. span (4).

RAILWAY MATERIAL.—Peckett 14in. by 22in. and 7in. by 12in. Steam Locos.; 3 miles 20 lb. Track, 24in. gauge bogies, turnouts, locos., &c.

STEEL PIPING.—10,000ft., 2in.; 5000ft., 8in. seamless; 1000ft., 12in. seamless; 500ft., 14in. seamless; 400ft., 18in. riveted; 280ft., 21in. o.d. welded flanged; 380ft., 21in. seamless flanged; 500ft., 24in. riveted; 1450ft., 27in. o.d. welded flanged; 216ft., 48in. riveted; 216ft., 60in. riveted.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.

VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock, all sizes, Parallel Slide Sluice, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—300, cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

SLING ENGINEERING WORKS,
COLEFORD, GLOS.
'Phone: Coleford 2271/2. E366 G

EIGHT UNUSED Dorrco Duplex Suction Pumps, Type W, No. 6, incorporating drive units with reduction gears, stroke-changing mechanism, and each complete with 3 H.P. motor.—BOX No. E1027, "The Engineer." G

Classified Advts. continued on page 10

FOR SALE

600

DIESEL ALTERNATOR SETS

600kVA, BRITISH POLAR/A.S.E.A., Engine vert., 5-cyl., two-stroke, air start, 250 r.p.m. Alternator 440/3/50.
330kVA PAXMAN/B.T.H., Engine 12-cyl., 12 RHP electric start, 1000 r.p.m. Alternator 440/3/50.
250kVA DEUTZ/SIEMENS SCHUCKERT, Engine 290 b.h.p. vert., 7-cyl., 4-stroke, air start, 500 r.p.m. Alternator 6300/3/50.
Two, 94kVA BLACKSTONE/E.C.C. Engine GPV. 3, 3-cyl. 4-stroke, air start, 600 r.p.m. Alternator 440/3/50.
94kVA BELLISS & MORCOM/L.D.C., Engine vert., 3-cyl., air start, 600 r.p.m. Alternator 440/3/50.
Quantity 31·2kVA CUMMINS Mobile Sets, Engine Series "A" 6-cyl., 4-stroke, electric start, 1000 r.p.m. Alternator 440/3/50. Mounted on pneumatic tyres.

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ABELSON

DIESEL LOCOMOTIVES FOR SALE (FOR 4′ 8½″ GAUGE)

(1) 150 H.P. Fowler 0-4-0 Diesel Mechanical Locomotive, rebuilt and as new, manufactured 1948. Tractive effort 15,000 lb.
(2) 150 H.P. Hunslet 0-4-0 Diesel Mechanical Locomotive, manufactured 1940. Tractive effort 15,000 lb.
(3) 100 H.P. Hunslet 0-4-0 Diesel Mechanical Locomotive, manufactured 1948. Tractive effort 7000 lb.
(4) 80/100 H.P. Andrew Barclay 0-4-0 Diesel Mechanical Locomotive, manufactured 1941. Tractive effort 8000 lb.
(5) 70 H.P. Avonside 0-4-0 Diesel Mechanical Locomotive, manufactured 1932. Tractive effort 6500 lb.
(6) 70 H.P. Hunslet 0-4-0 Diesel Mechanical Locomotive, manufactured 1940. Tractive effort 7000 lb.
(7) 40 H.P. Simplex 0-4-0 Diesel Mechanical Locomotive, suitable for light shunting in works.
All these engines are in good mechanical order and available immediately from stock.

ABELSON & CO. (ENGINEERS) LTD. Coventry Road, Birmingham, 26. Tel.: SHEldon 2424.
60/62, Clapham Road, London, S.W.9. Tel.: RELiance 7081.
100, Oxford Road, Manchester, 13. Tel.: Ardwick 1328. E6688 G

600

DIESEL LOCOMOTIVES

Virtually unused and in first-class working order.
RUSTON & HORNSBY 20 DL 16/20 h.p., 2ft. (60 cm.) gauge, powered by Ruston engines.
HUDSON HUNSLET 20, 25 and 30 h.p., 2ft. (60 cm.) gauge, powered by McLaren Ricardo and Ailas Craig engines.
HIBBERD Planet 16/30 h.p., 2ft. (60 cm.) gauge, powered by National engines.
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WOOD LANE, LONDON, W.12.
Tel.: Shepherds Bush 2070 ; and
STANNINGLEY, NR. LEEDS.
Tel.: Pudsey 2241. E205 G

AIR HYDRAULIC ACCUMULATOR AND PUMPING EQUIPMENT

Comprising Air Hydraulic Accumulator by Hydraulik of Duisburg, with four 20ft. by 3ft. Air Bottles, one Water Bottle, capacity 1000 litres, working pressure 3000 lb. per sq. inch, with latest type electronic control, with three Three-Throw Hydraulic Pumps, each driven by 275 h.p. motor, 400 volts, 3 phase, 50 cycles—modern equipment available for immediate delivery.

REED BROTHERS (ENGINEERING) LTD, Replant Works, Woolwich Industrial Estate, London, S.E.18.
Tel.: Woolwich 7611 (6 lines). E968 G

GRINDING MACHINES

SNOW T.14 and T.20 TABLE SURFACE GRINDING MACHINES ; grinding wheels 14in. and 20in. diameter.

F. J. EDWARDS LTD.
359, EUSTON ROAD
LONDON, N.W.1.
EUSton 4681. E7221 G

DUFFRYN RHONDDA COLLIERY,
Port Talbot, Glam.

Two 10,000 c.f.m. Brown-Boveri Turbo Compressors, complete with surface condenser, circulating pumps and extraction pumps. The turbines are built to operate at 155 lb. per square inch and at a temperature of 535 deg. F. The compressors deliver 10,000/12,500 c.f.m. at 80 lb. per square inch. Both machines in good condition and perfect running order.—Arrangements to inspect can be made with Area Purchasing and Stores Manager, National Coal Board, Area No. 2, Tondu, Nr. Bridgend, Glam. E7213 G

CRAIG & DONALD 26ft. by ⅜in. Plate Bending Rolls, 15in diameter rollers.—BOX No. E7222, "The Engineer." G

FOR SALE

SERVICE EDWARDS VALUE!

NEW MUBEN Bar and Angle Shear, Model KSG100, all-steel build, motorised 400/3/50, complete with blades for flat bars, rounds and squares ; capacity : rounds 2in., squares 2in., flat bars 10in. by ¾in., angles up to 4in. by ½in.; other sections in proportion.
BESCO Heavy Universal Edging, Bending and Folding Machine, lift of top beam 6in., capacity 74in. by 14 s.w.g., complete with angle stop, adjustable back gauge and two blades.
BESCO Size R150/10 Press Brake, steel plate build, motorised 380/420/3/50, pressure 150 tons, forming capacity 10ft. by 3/16in. with die opening 1¼in., stroke 3in., gap depth 12in., maximum strokes per min. 20.
RHODES Power Geared Bending Roller, bench type, belt drive, capacity 49½in. by 16 s.w.g. mild steel, diameter of rolls 3in. Weight about 8 cwt.
ROBERTSON Gang Slitting Machine, adjustable gauges, cutters fitted 10in. by ½in., capacity ½in. thickness, between housings 24in. Weight 45 cwt.
SCHULER Type AAC, Size No. 2, Double-Sided Geared Press, tie rod frame, motorised 440/3/50, pressure approx. 90 tons, stroke adjustable 1½in. to 4 11/16in., between uprights 23½in.
Photographs of the above are available.
MACHINE TOOLS, NEW AND USED, Of Every Description. Attractive Prices.

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359–361, EUSTON ROAD,
LONDON, N.W.1.
Telephone : EUSton 4681–3771 ;
and at
LANSDOWNE HOUSE, 41, WATER STREET, BIRMINGHAM, 3.
Telephone : Central 7606–8. E209 G

600

D.C. GENERATORS

Quantity of 24kW and 15kW compound-wound, 100-volt D.C. Generators, by L.D.C., E.C.C. and E.E.C., drip-proof frames, ball/roller bearings, various speeds between 1440 and 1625 r.p.m.
Available for prompt delivery.

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SONS AND CO. LTD.,
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Tel.: Pudsey 2241. E200 G

TWW

BLISS 3½B DOUBLE-ACTION TOGGLE PRESS, punch stroke 12in., distance between slides 26in., 400/3/50.
BLISS 408A DOUBLE-ACTION TOGGLE PRESS, punch stroke 25in., outer stroke 17in., bed 72in. by 50in., die cushion, 400/440/3/50.
NEW BENTLEY 80-TON GEARED POWER PRESS, adjustable stroke, 400/3/50.
NEW BENTLEY 30-TON INCLINABLE POWER PRESS, adjustable stroke, 400/3/50.

THOS. W. WARD, LTD.
ALBION WORKS - - - SHEFFIELD.
'Phone : 26311. 'Grams : "Forward." E213 G

600

AIR RECEIVERS

7ft. diam. by 30ft., riveted, 120 p.s.i. W.P.
6ft. by 14ft. 8in. CO_2, riveted, 120 p.s.i. W.P.
Twenty-eight 5ft. 4in. diam. by 6ft. 11in., riveted, 70 p.s.i. W.P.
Also New Vertical Welded Air Receivers, 2ft. to 4ft. diam. by 6ft. by 12ft. on the straight, 100 p.s.i. W.P.

GEORGE COHEN,
SONS AND CO. LTD.,
WOOD LANE, LONDON, W.12.
Tel.: Shepherds Bush 2070 ; and
STANNINGLEY, NR. LEEDS.
Tel.: Pudsey 2241. E203 G

HYDRAULIC PRESSES

from
10,000 TONS
down to
10 TONS.

We can offer from available stock Hydraulic Presses of all types for forging, extrusion, forming, drawing, rubber and plastics moulding, &c.

Consult the Specialists

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DEMM Model RS800 Hydraulic Spline Grinder, motor drive, distance between centres 31½in., max. length ground 23½in., dia. ground 3½in., height of centres 5½in., spindle speed 3800 r.p.m.
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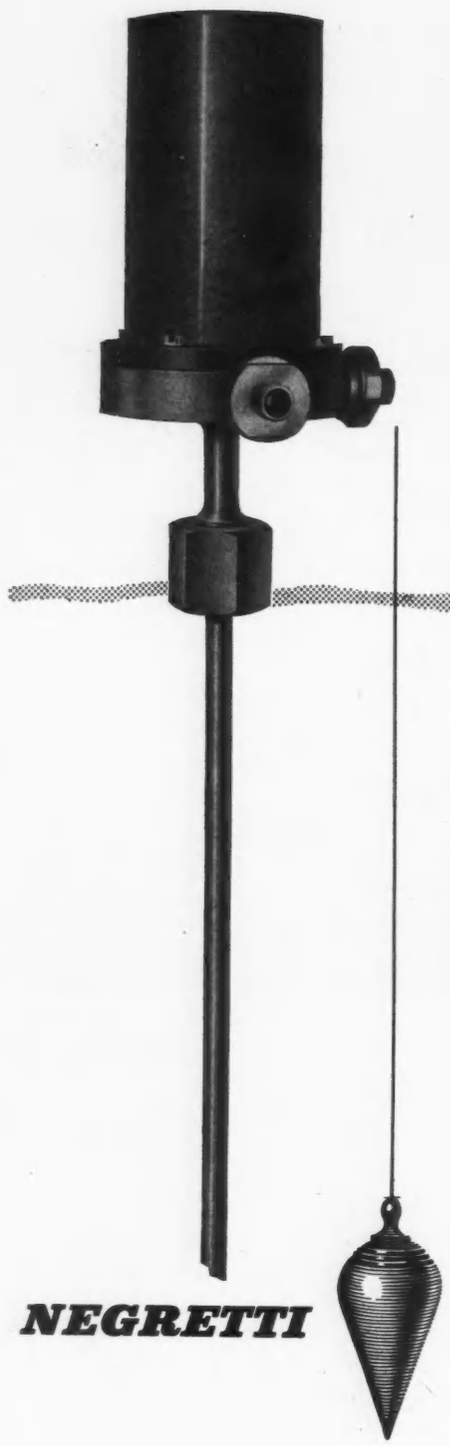

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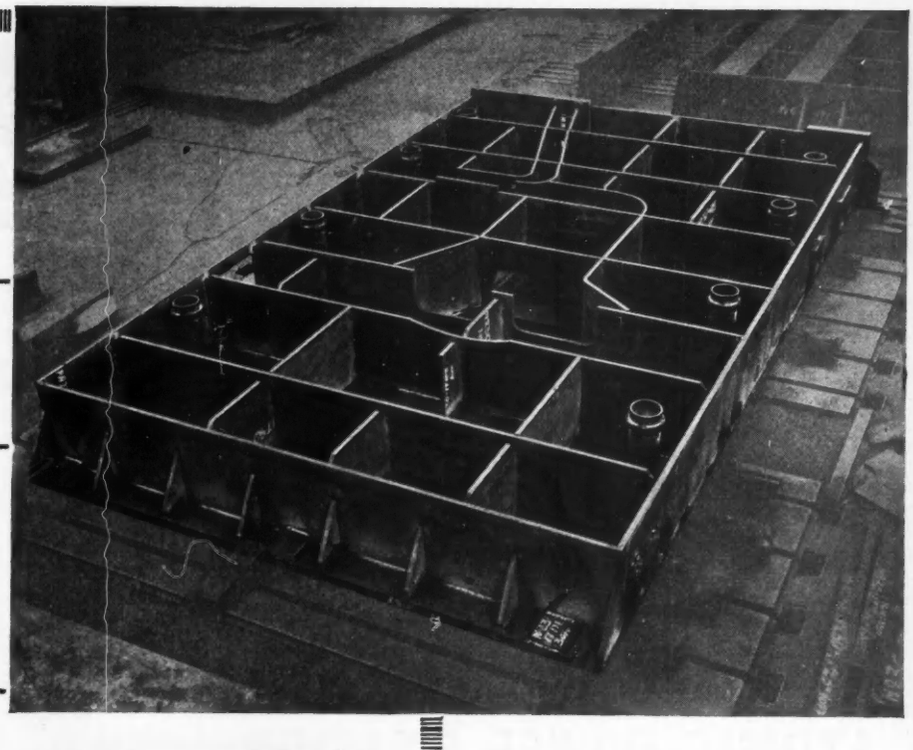

Turbine Bedplates during construction showing internal ribbing, etc. Total finished weight approx. 7 tons.

Photograph by courtesy of C. A. Parsons & Co., Ltd., Newcastle-on-Tyne.

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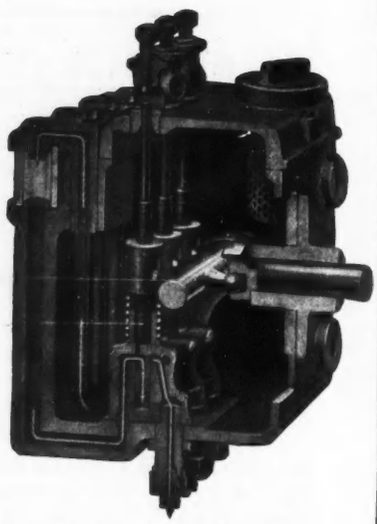

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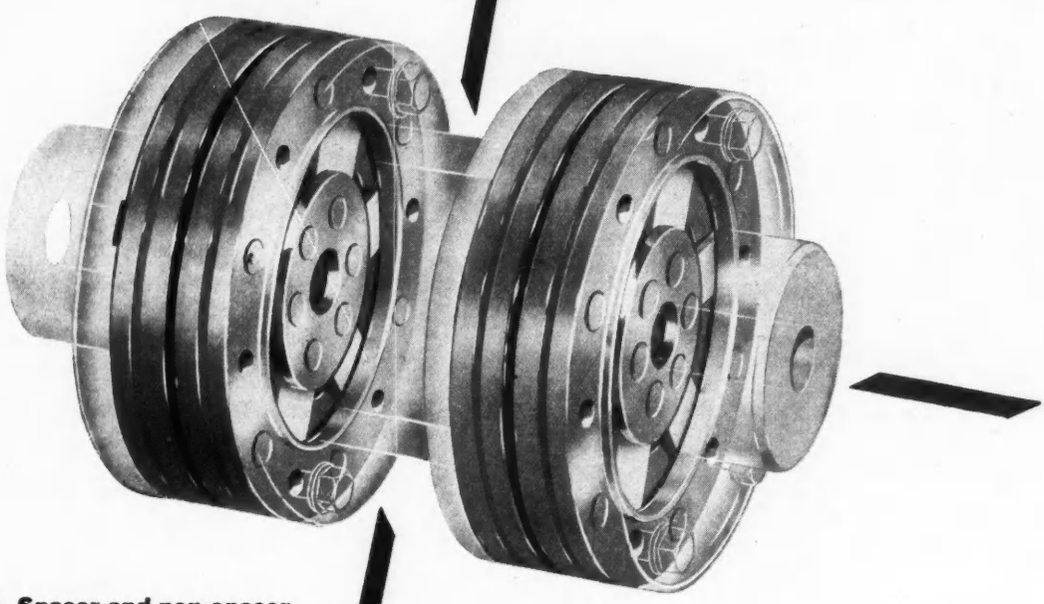

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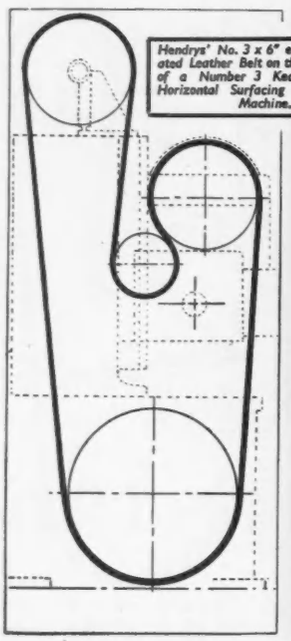

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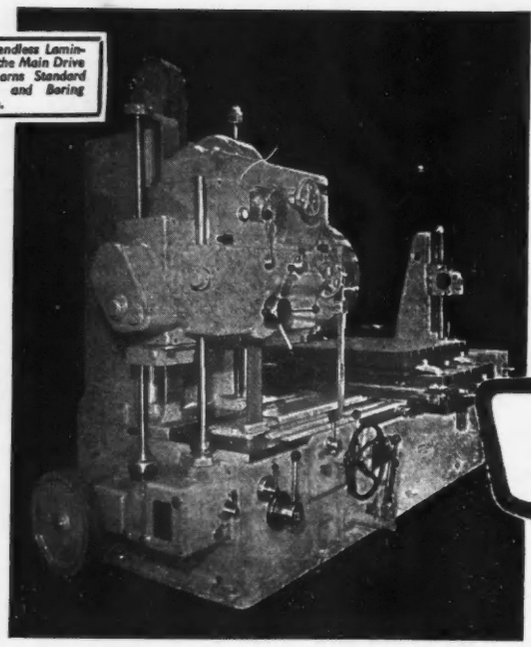

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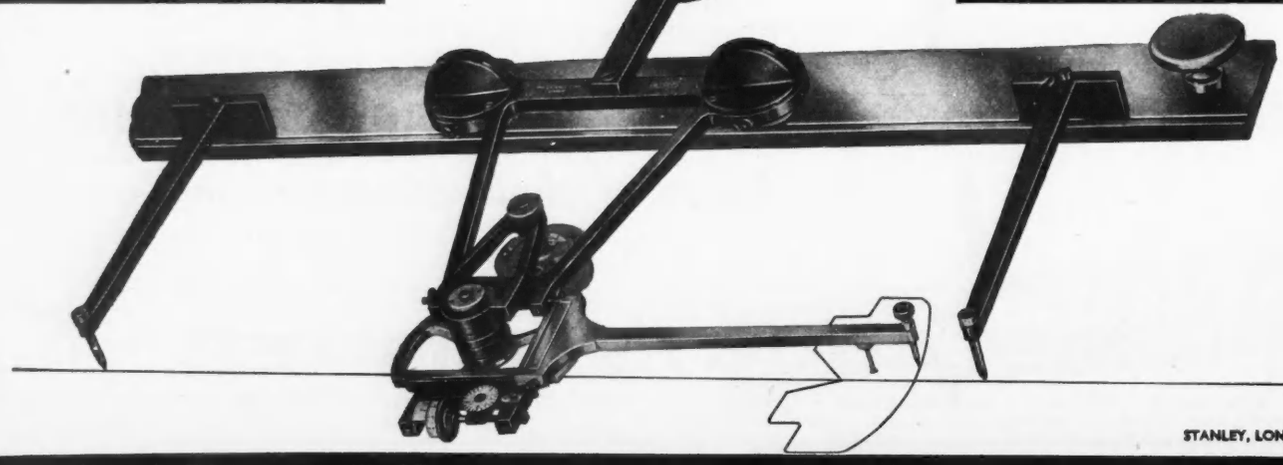

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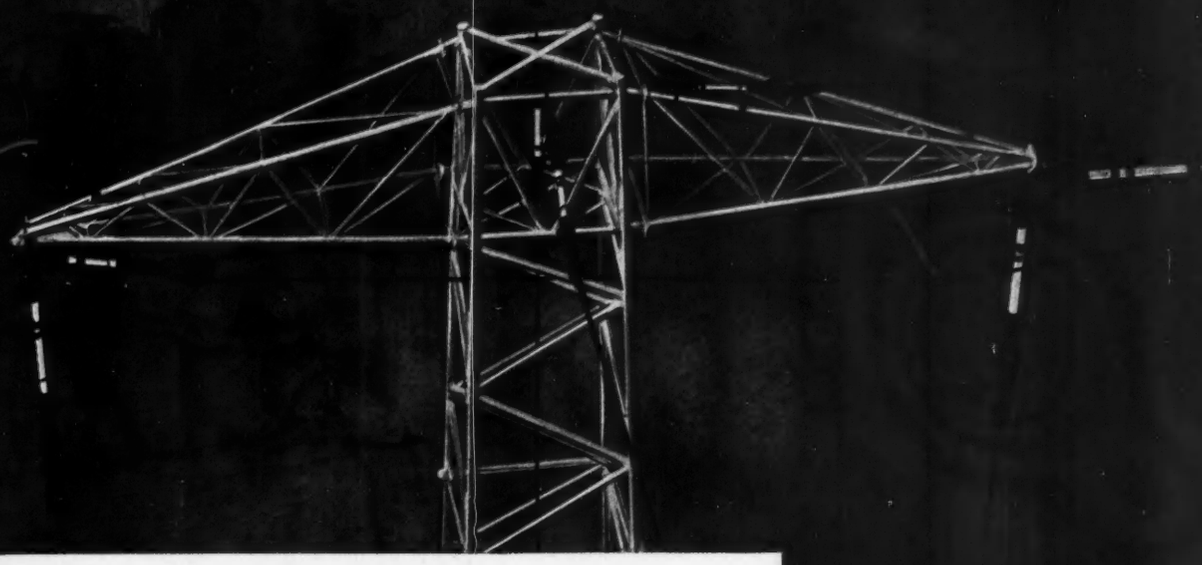

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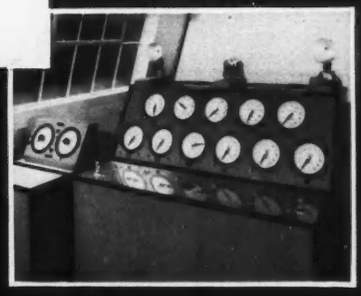
Right: A Pullmeter. Below right: Load and deflection indicators



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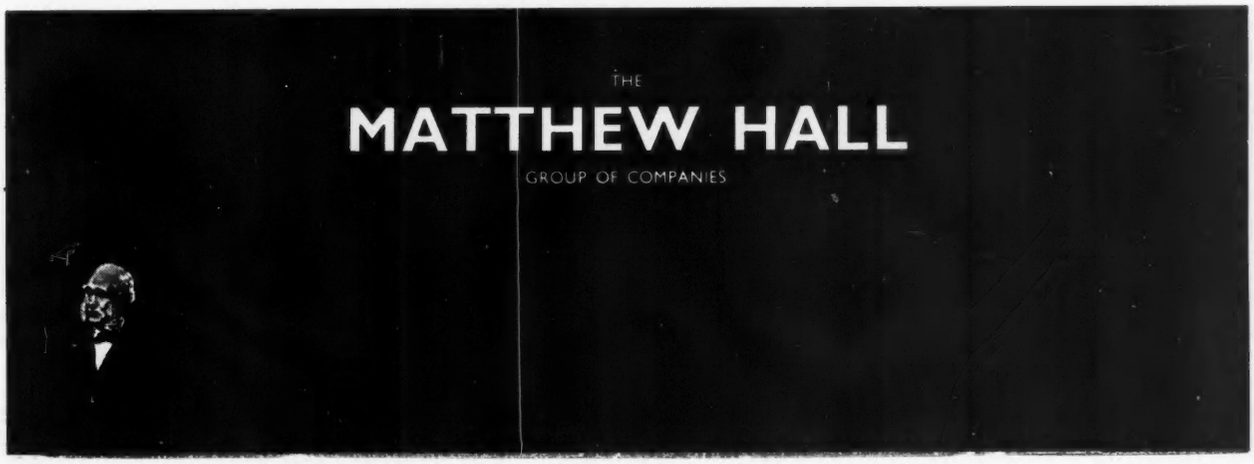

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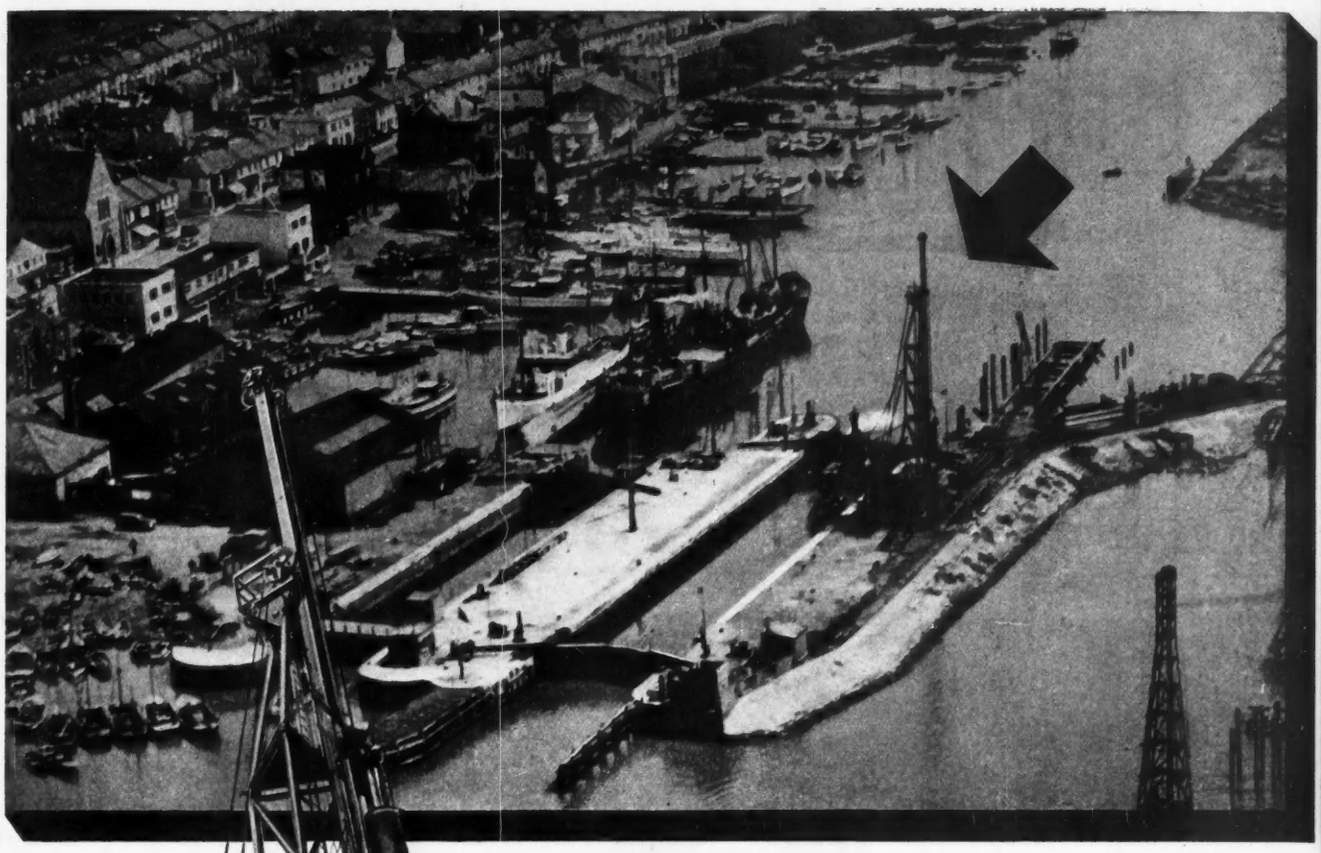

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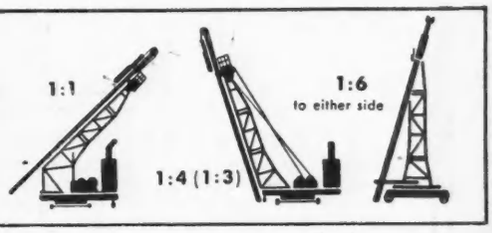

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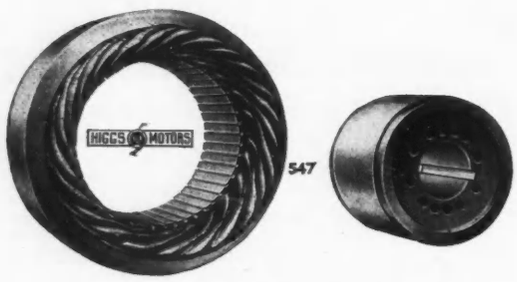

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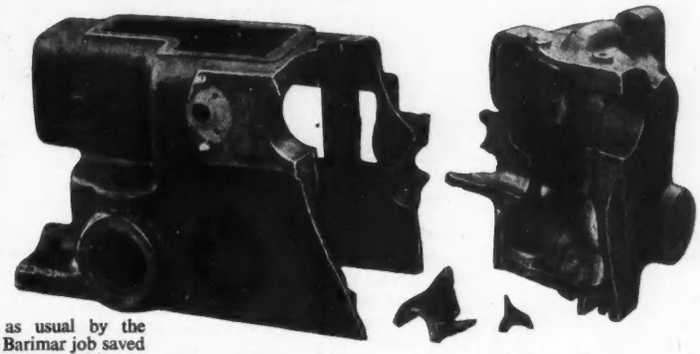
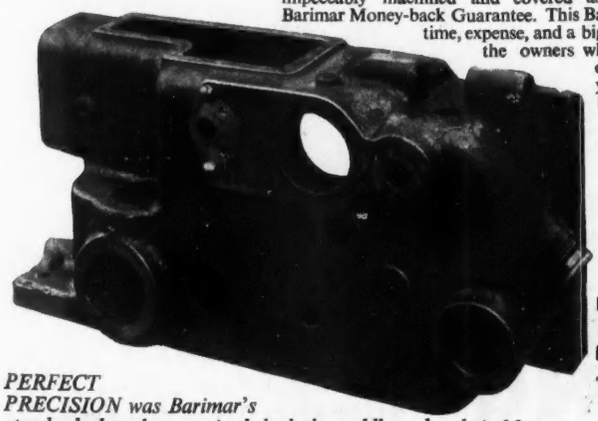


Many lathe saddles have been repaired by Barimar. This one was broken right through the surface feed housing.



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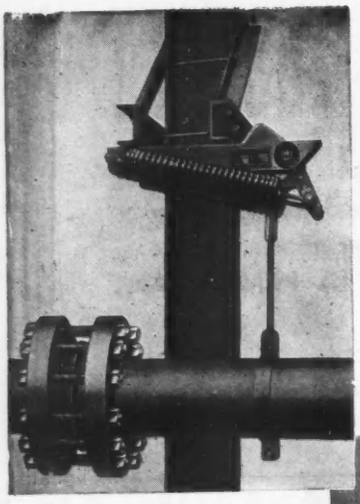

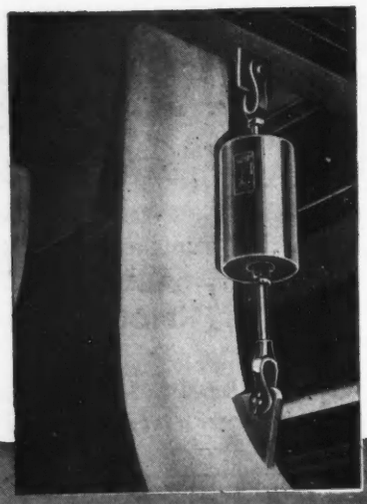

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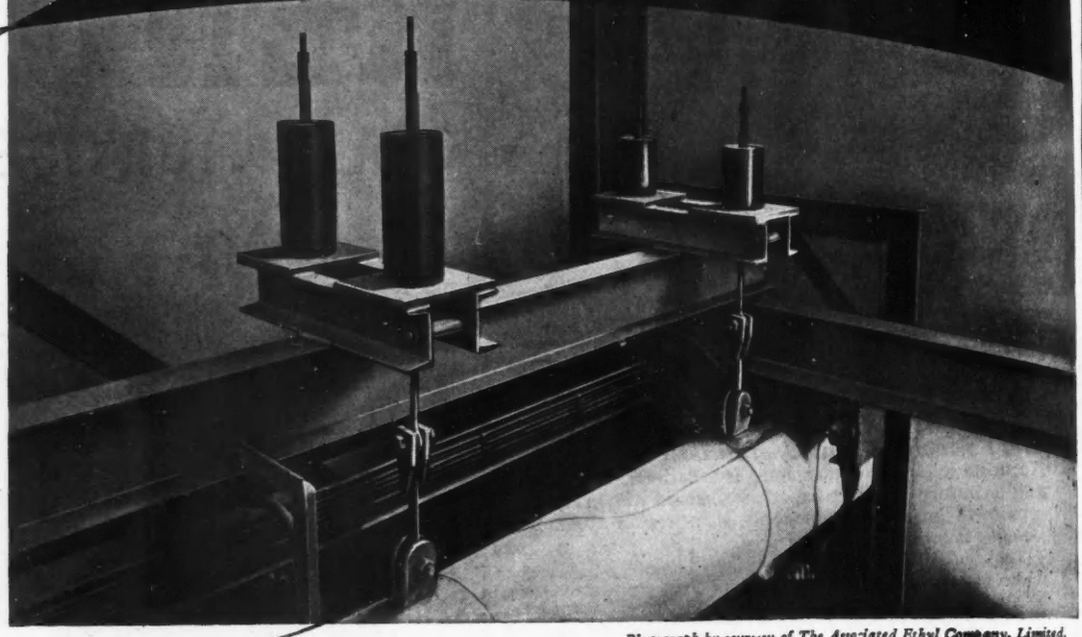

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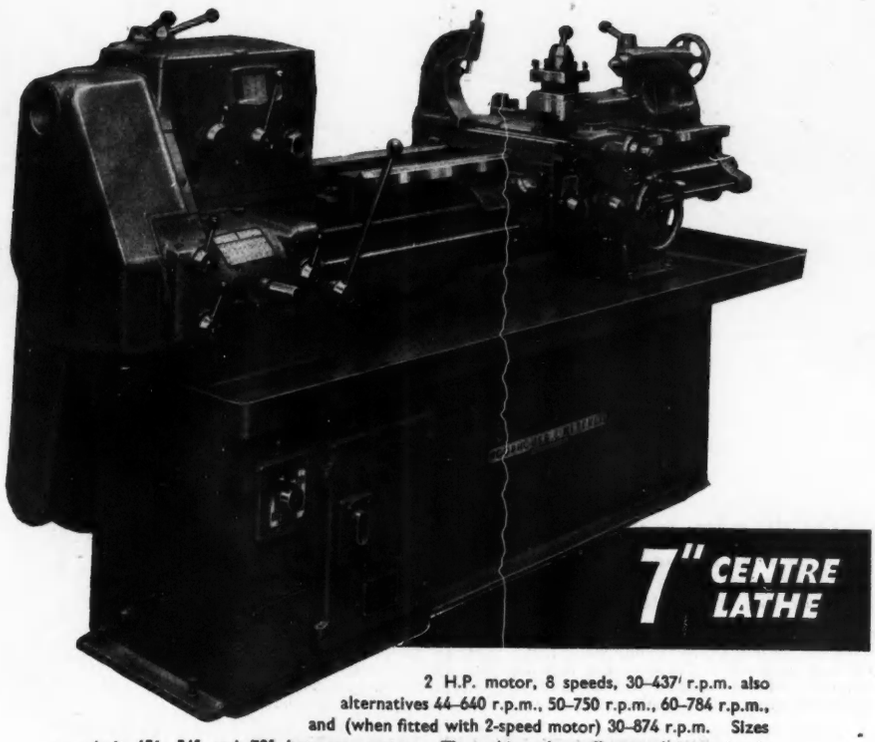

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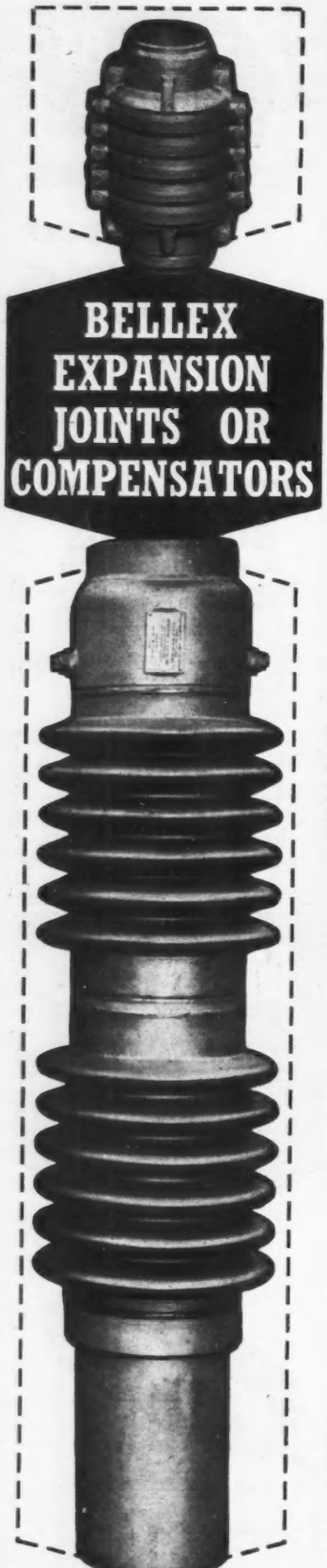

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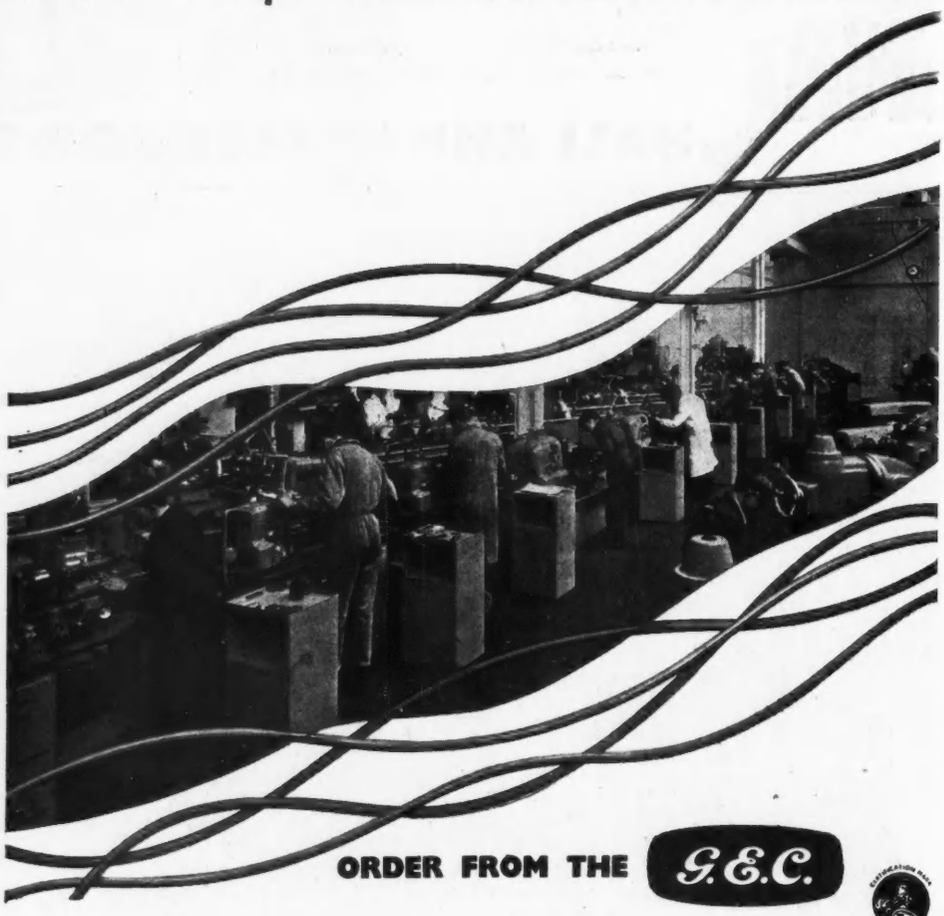

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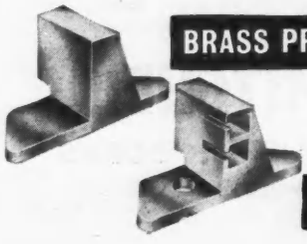

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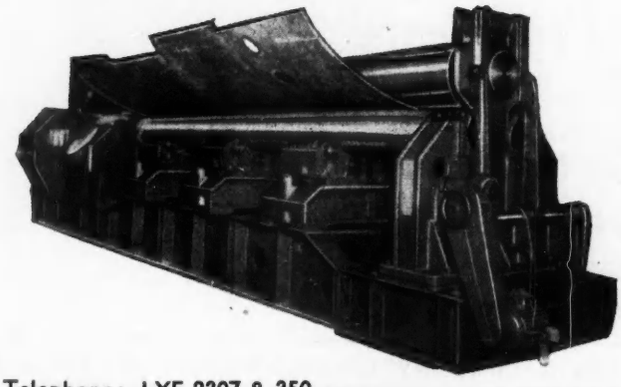

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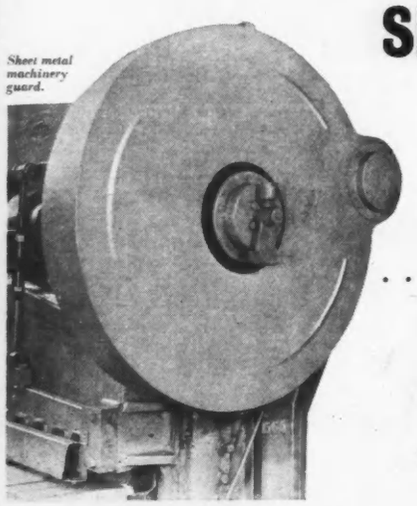

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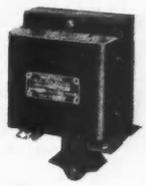

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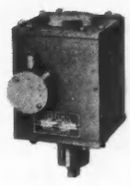

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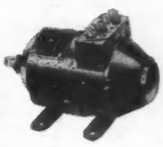

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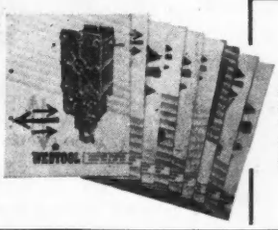

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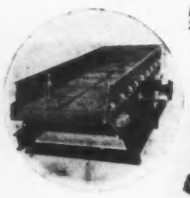

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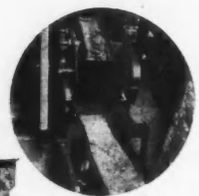

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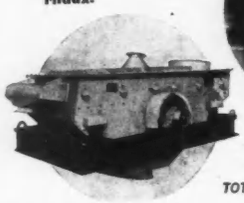

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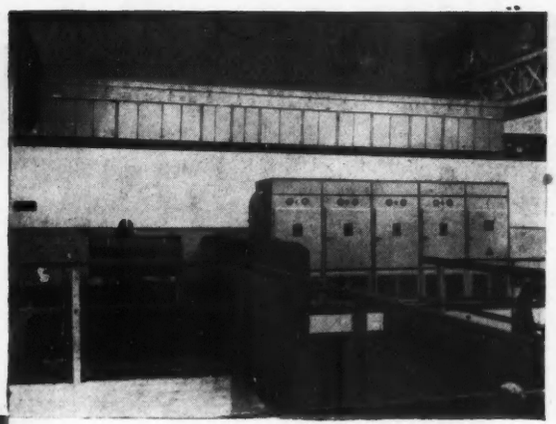

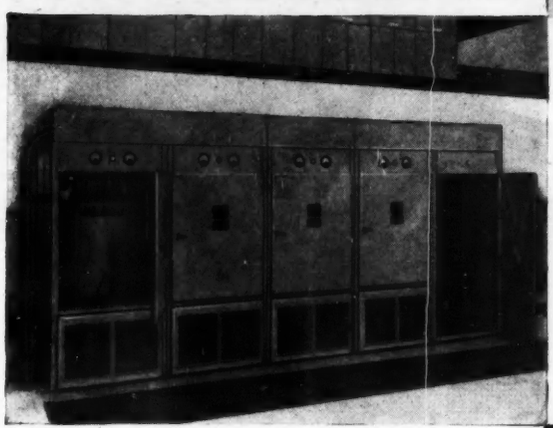

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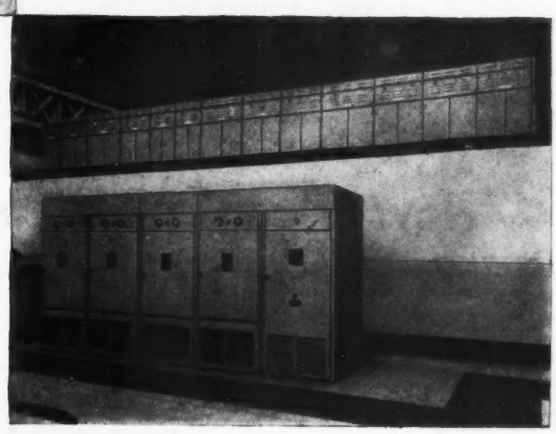

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C/A 601

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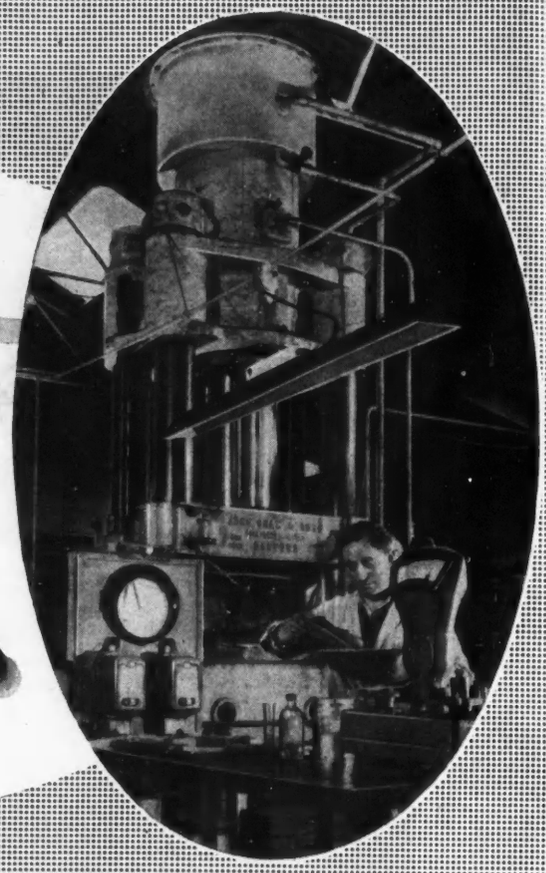

Weighing carbon and 'Fluon' p.t.f.e. before moulding the block from which the components are machined.

Now 'Fluon' p.t.f.e. in brushes and mechanical components gives greatly reduced wear

A NEW RANGE of electrical brushes, immune from the catastrophic effects of extreme cold or high altitude use are made from carbon mixed with 'Fluon' polytetrafluoroethylene. 'Fluon' is a versatile plastic material with a very low coefficient of friction. Apart from its electrical uses it is also valuable for making light duty bearings required to work without lubrication.

Among its other remarkable characteristics, 'Fluon' p.t.f.e. is chemically inert and unaffected by all known corrosives except fluorine compounds and molten alkali metals. Because of this it is ideal for gaskets, packings, seals and couplings. 'Fluon' is non-adhesive, non-wetting, tough and resilient. Its working temperature range extends from 250°C right down to –80°C.

'FLUON'

'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.

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PF.25

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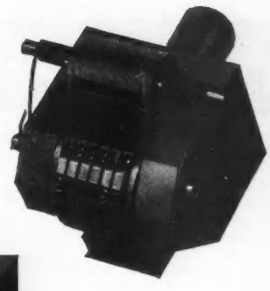

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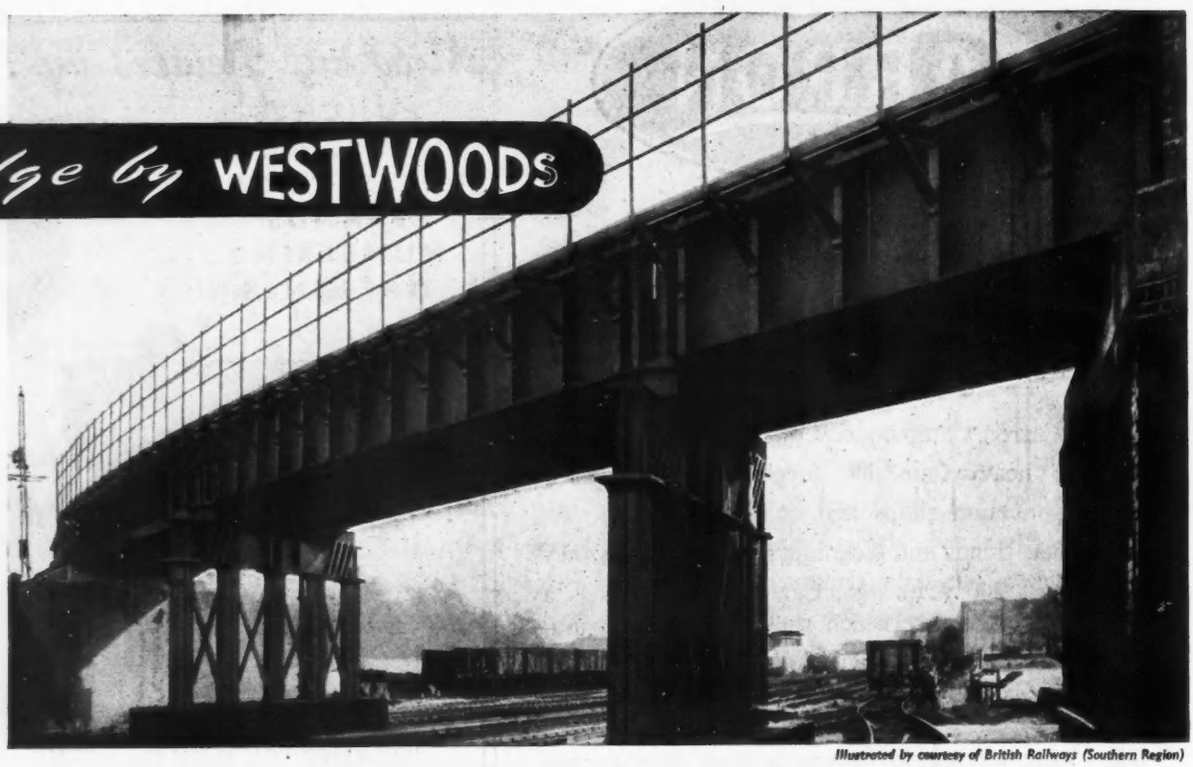
Bridge by WESTWOODS



Illustrated by courtesy of British Railways (Southern Region)

Bridge and Constructional Engineers, Manufacturers of Pressed Steel Troughing, Mechanical Grabs, Sheet Metal Equipment and Steel Stock Holders.

Twickenham Flyover. This bridge is curved in plan, and each of the three spans was completely welded at works and delivered by road and rail to the site. Max. length 75 ft., width 15 ft.

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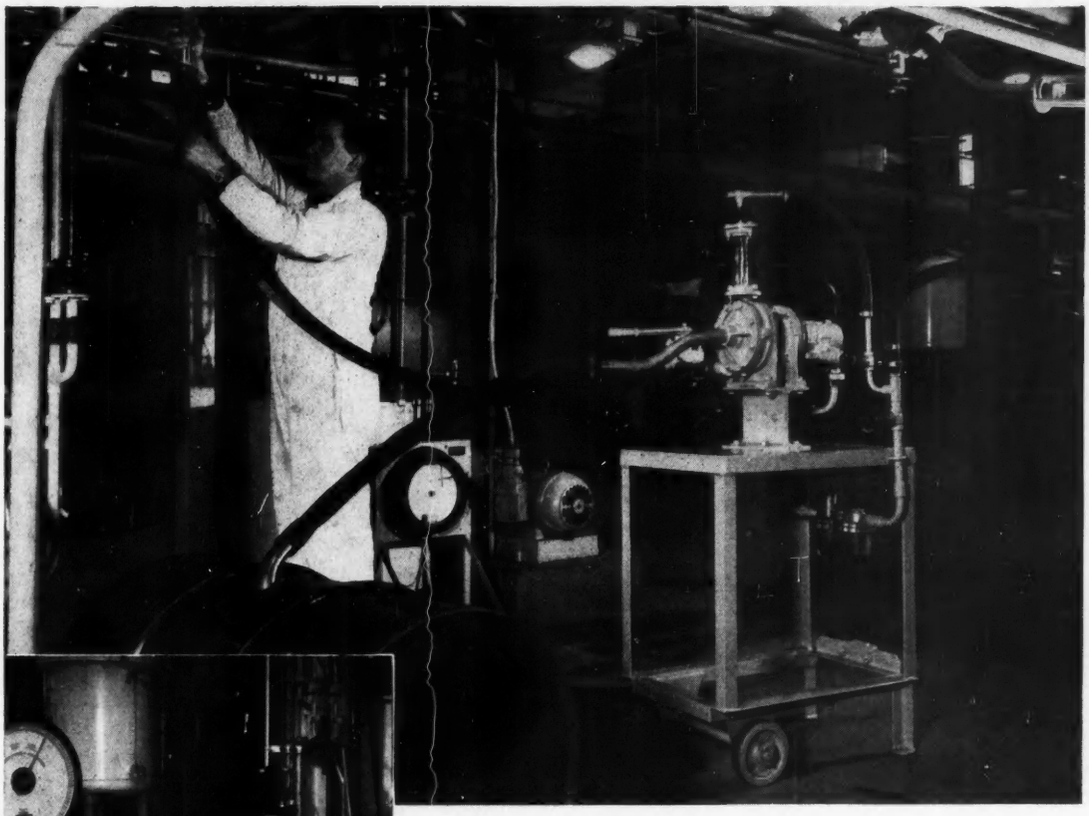
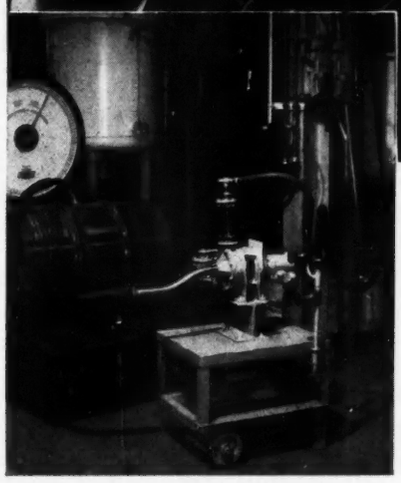
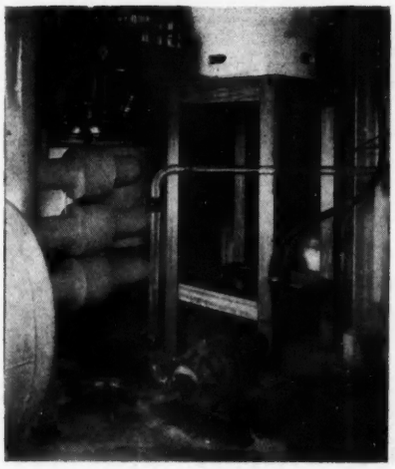




Photographs taken in their Beeston factory by courtesy of Boots Pure Drug Co. Ltd.



When the Pump must go to the Fluid . . .

Boots Pure Drug Company Limited, in the manufacture of corticosteroids, find it more practical in some of their operations to take their pumps—Safran compressed air driven units—to the fluid, coupling up their power with conveniently located air points. In the illustrations, two of these transportable units are shown pumping inflammable solvents in a flame-proof area. One fixed unit is also shown. The pumps are $\frac{3}{4}$"/1" stainless steel (FMB) units fitted with 1 BHP Holman Air Motors. Running speed is 2700 R.P.M. to handle 600 gallons of fluid per minute at 48 ft head.

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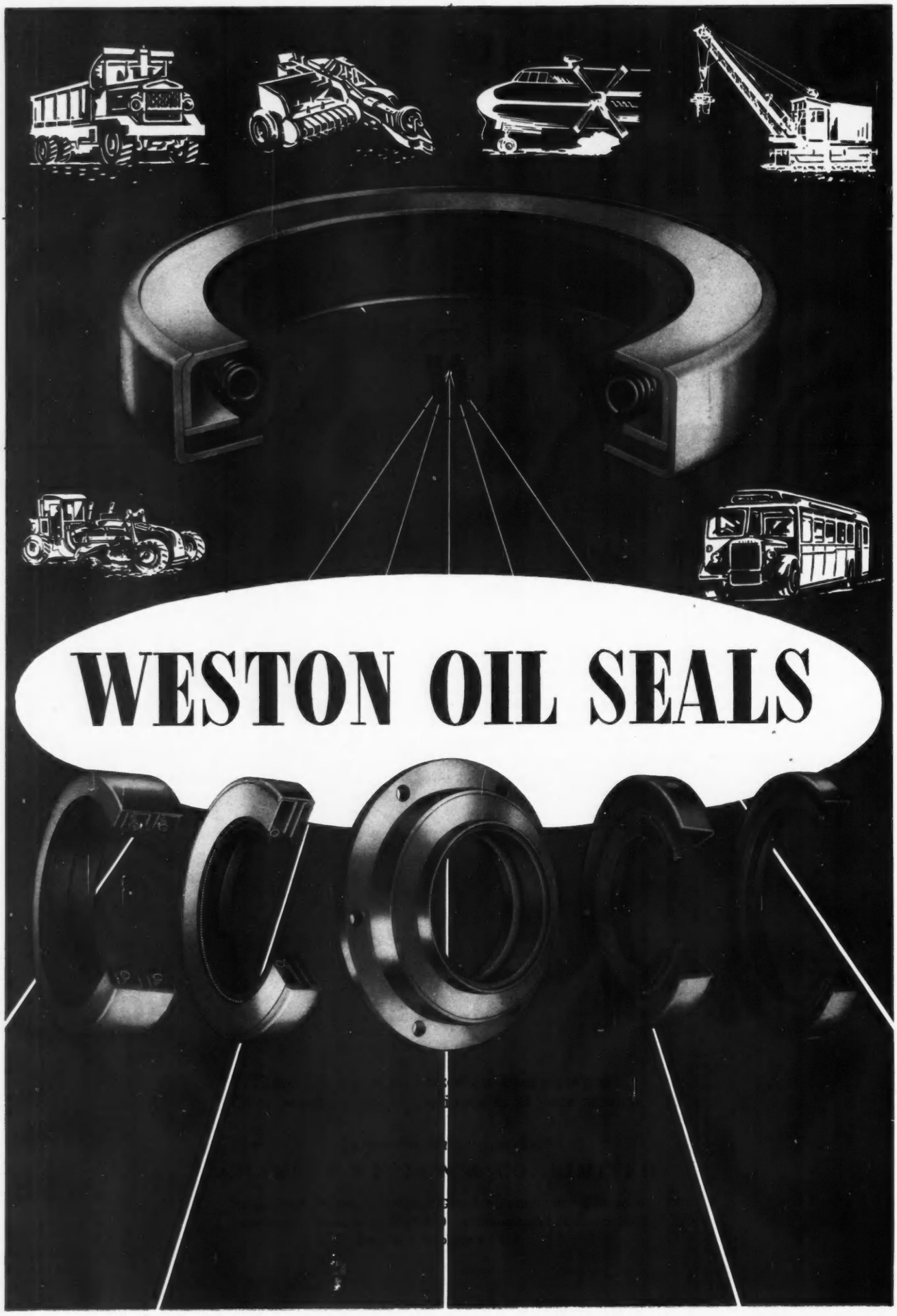

WESTON OIL SEALS

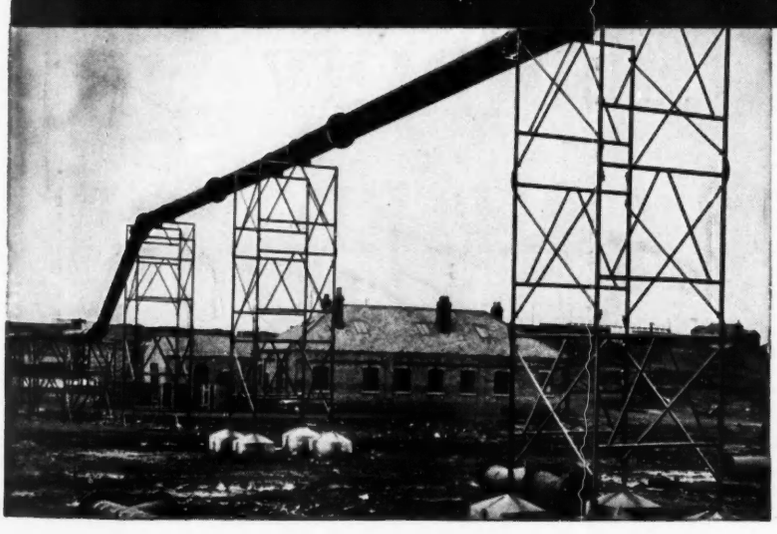
for all industrial purposes

Versatility in application is one of the outstanding characteristics of Sterling Safway Unit Frame Scaffolding. These pre-fabricated unit frames have been successfully employed in an astonishing diversity of ways — a few of which are shown in this advertisement, but other unusual uses include ski-run towers, wind tunnels, movable rock drilling stages etc. No other form of scaffolding is so adaptable or so easy to assemble.

On left: Rail canopy in use at Lever Bros.

However, it is not merely for the unusual job that Sterling Safway stands pre-eminent. For every normal use in building and constructional work, large or small; for maintenance and decoration inside or outside; for ships' stages and all engineering and industrial uses, Sterling Safway Unit Frame Scaffolding is supreme — because half the work is done before it reaches the site, which saves time, money and labour.

On right: Cross Berth Gangway at Messrs. Swan Hunter and Wigham Richardson, Neptune Yard, Walker-on-Tyne.



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GLASGOW

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On left: Safway Scaffolding supporting a Gas Main built by the Coppee Company Ltd.

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The six finishing stands of the 80" continuous hot strip mill at Abbey Works

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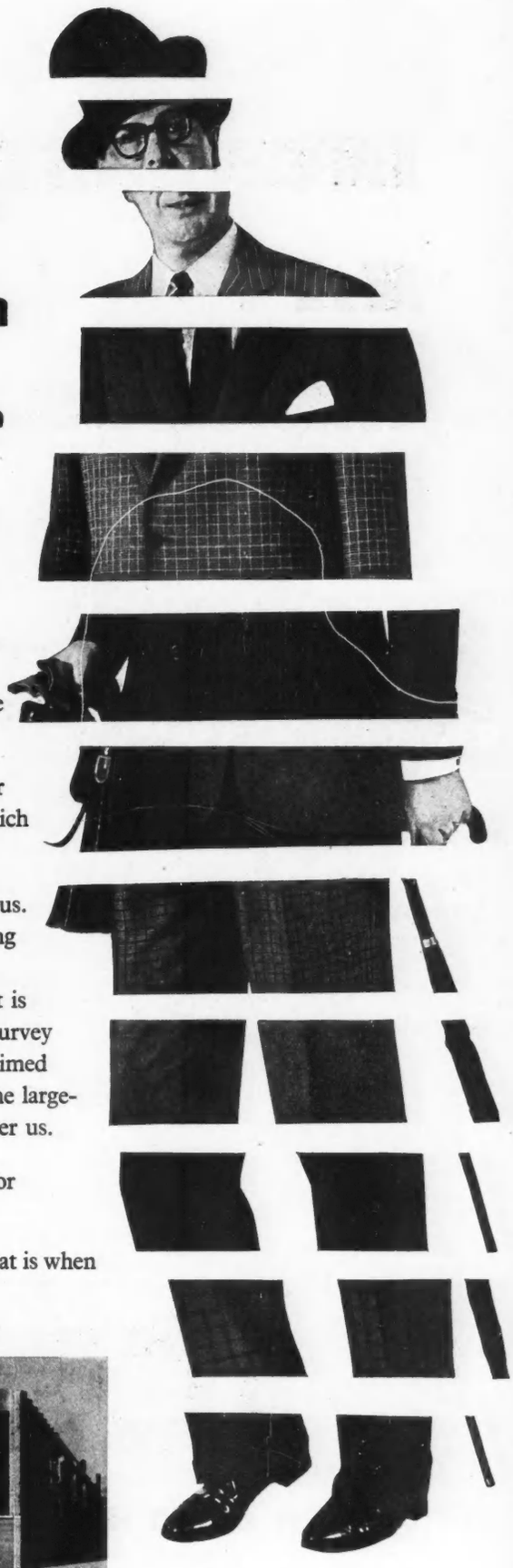
today, only twelve men are our potential customers!



At any one time perhaps only a dozen men in Britain are considering buying what we have to sell. They are among the chief executives of this country's industry — and each is at this moment faced with the once-in-a-lifetime decision of building a new factory.

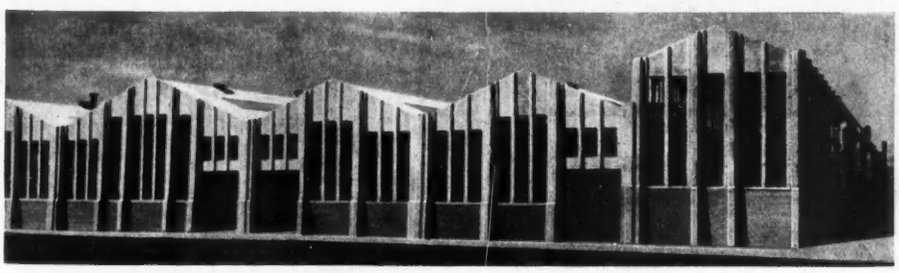
The decision is one which will shape their own lives, the prosperity of their companies and the well-being of all who work for them. It is a decision which leaves no margin for second best.

Beecham Buildings

That is why the wise will buy from us. We say it without diffidence, knowing that we are unique in offering *new ways* of building. Every contract is kept under one control. From first survey to final finishing every operation is timed to ensure maximum production efficiency and minimum site delay. With the large-scale use of intelligently-planned factory production, weather does not hinder us.

Costs are cut and work is speeded so that a client's capital is put to work for him much earlier.

Today, next month, next year, you may be among our dozen executives. That is when you need Beecham Buildings. May we come to see you?



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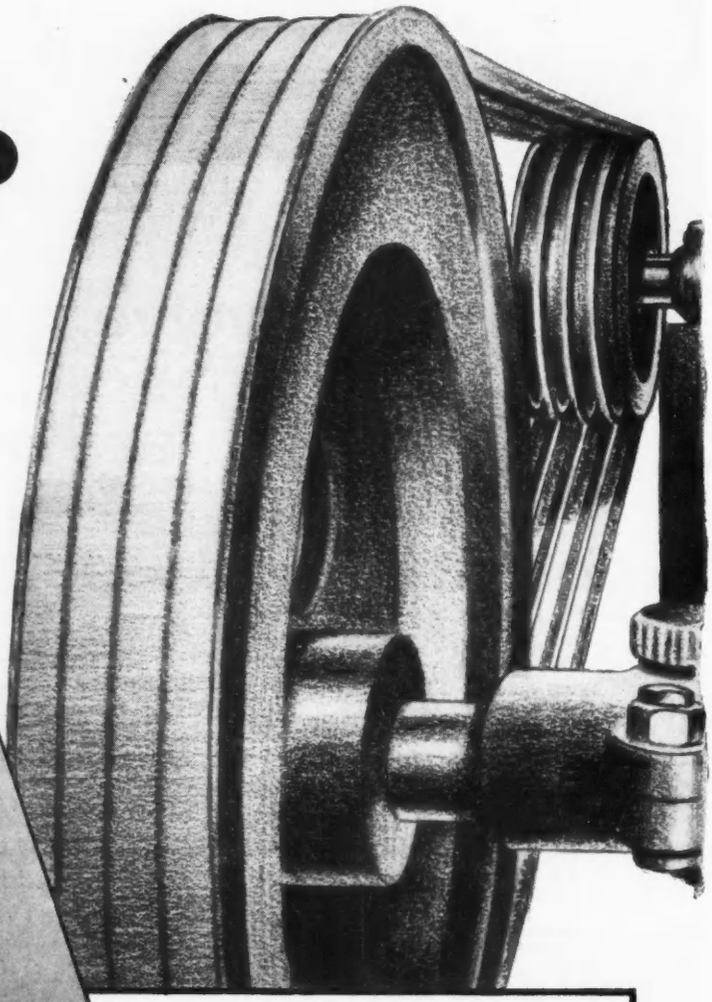

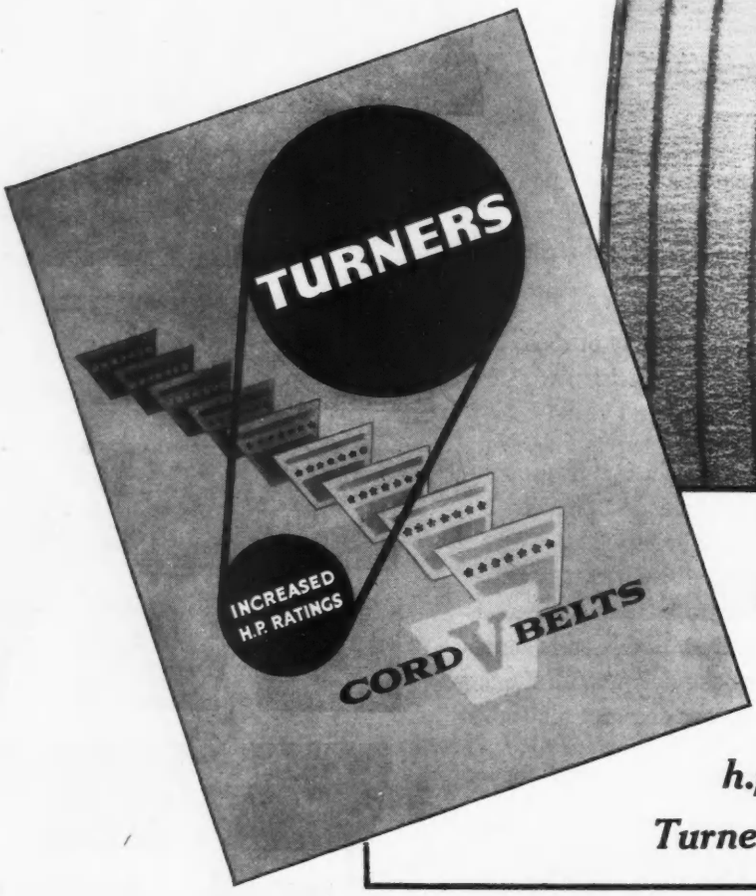

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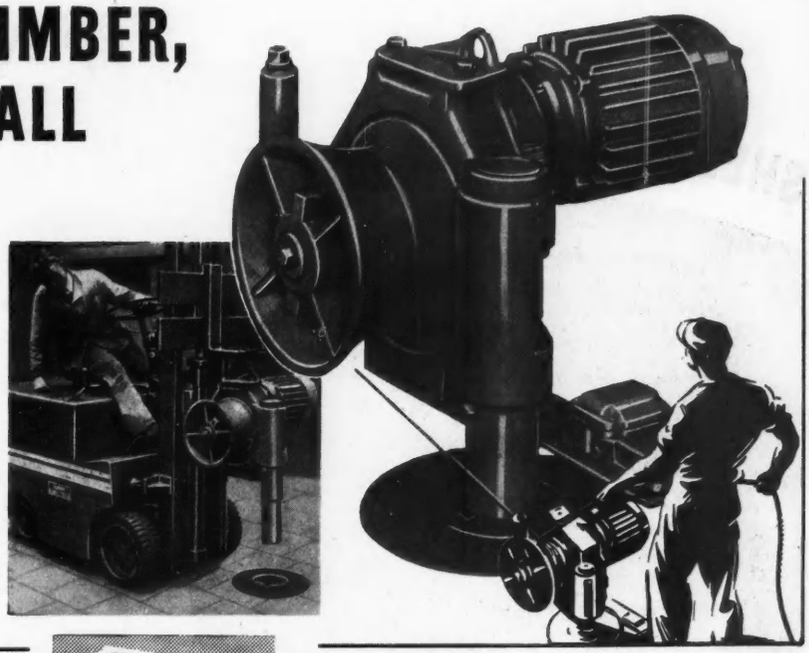
THE SADI CAPSTAN IS TRANSPORTABLE



Photograph illustrates unit being lifted from ground socket by Standard Fork Truck.

Ask for Literature E457

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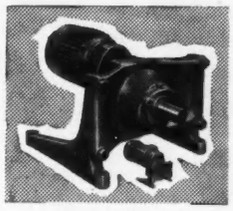
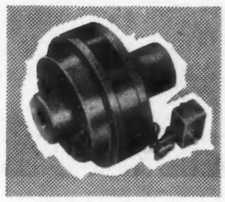
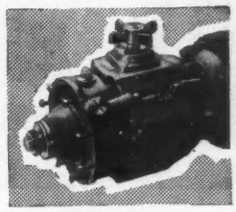


Geared Motor



A.S. Safety Coupling



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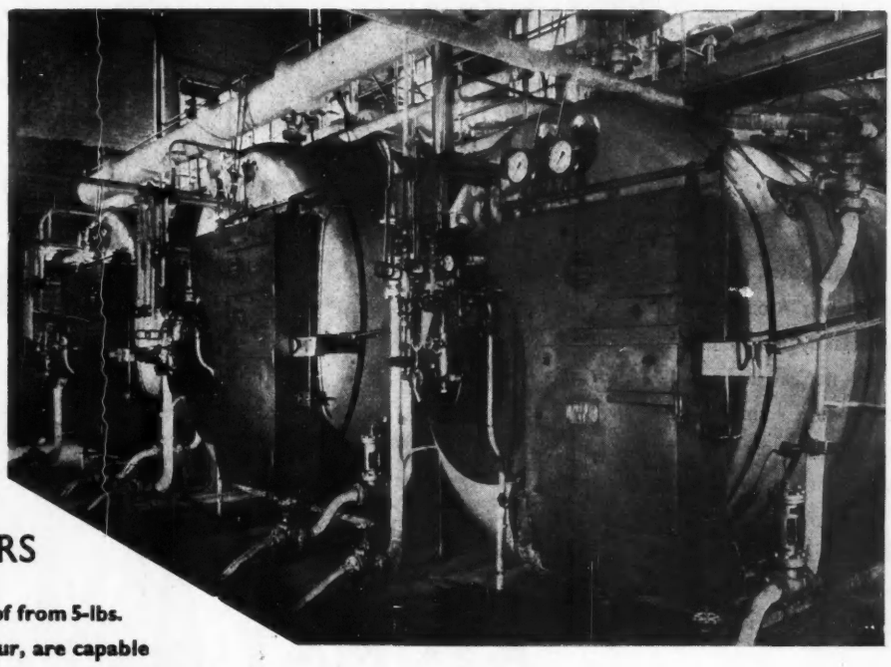

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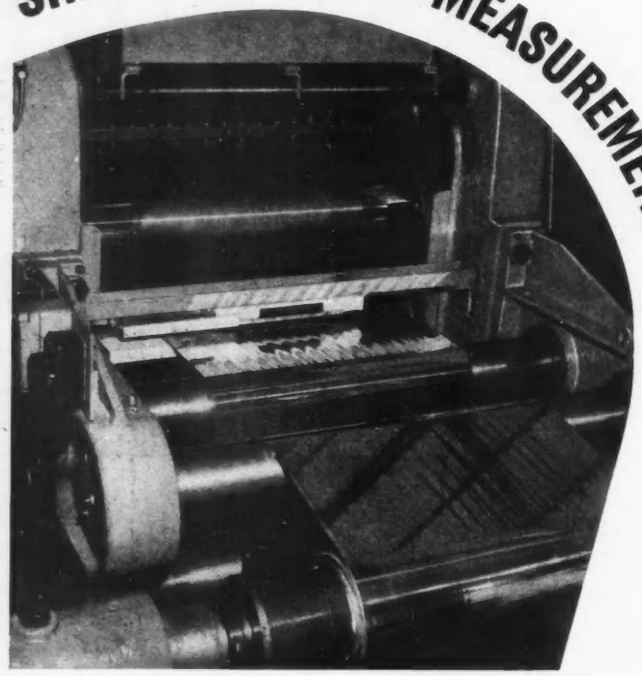

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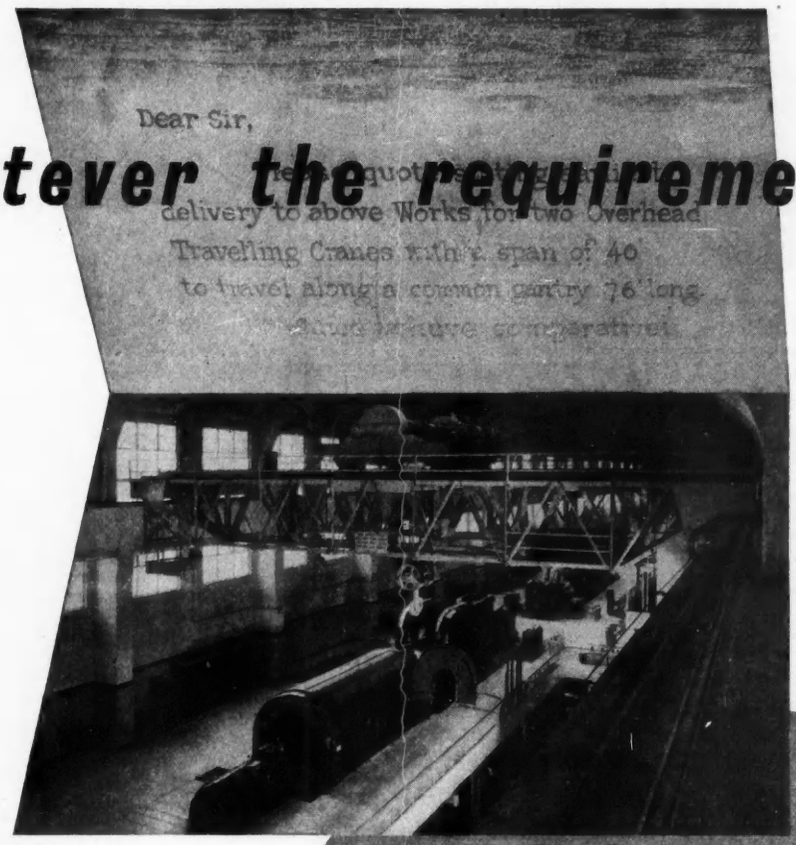
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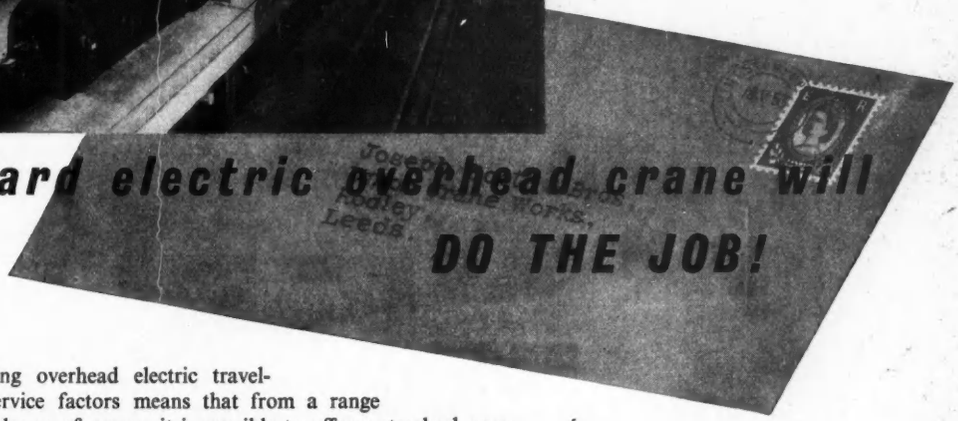

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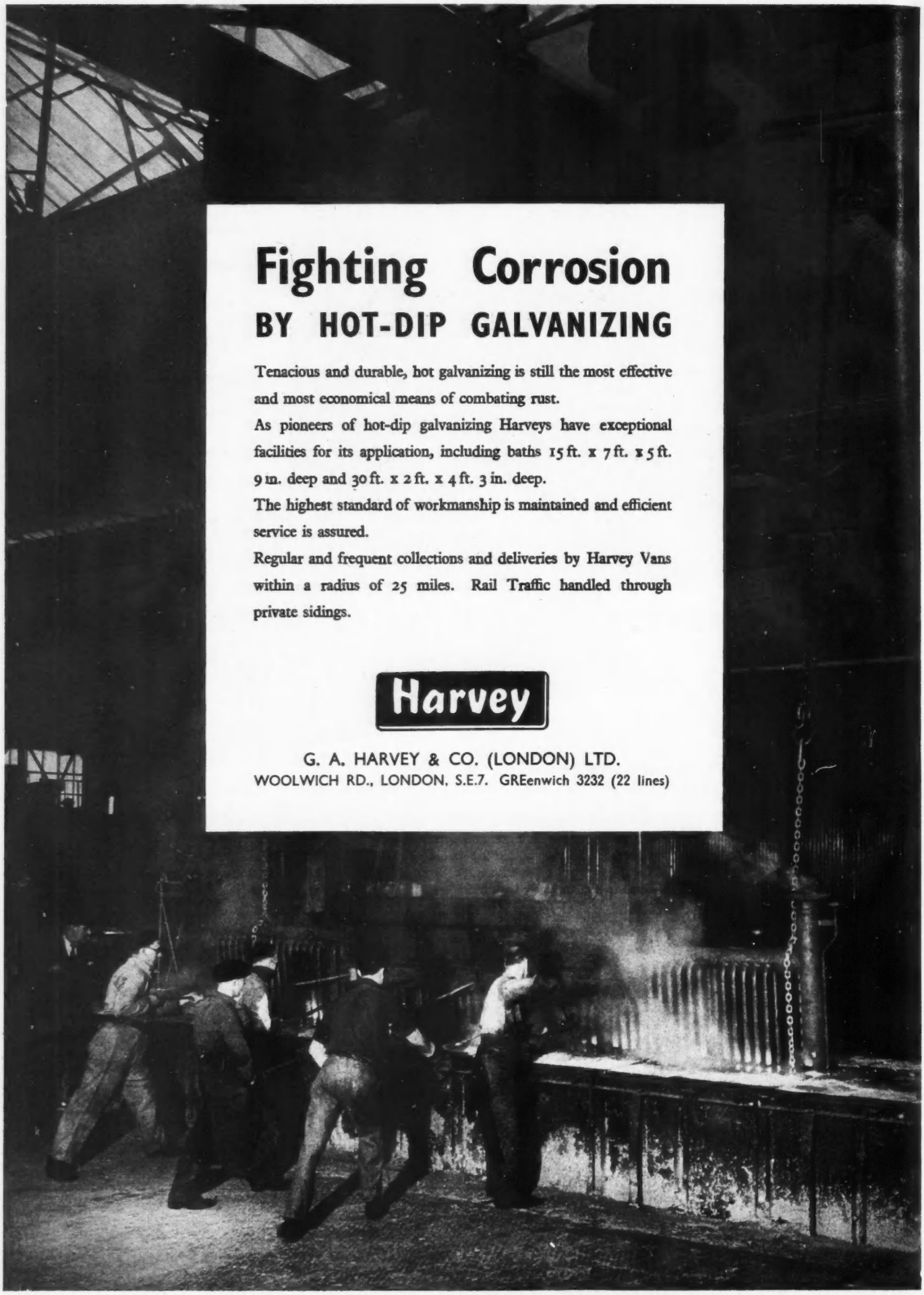

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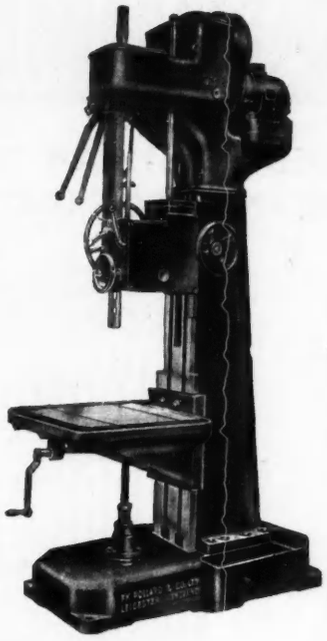
UPRIGHT DRILLING MACHINES



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Box Column Models supplied in Gang Drill Form

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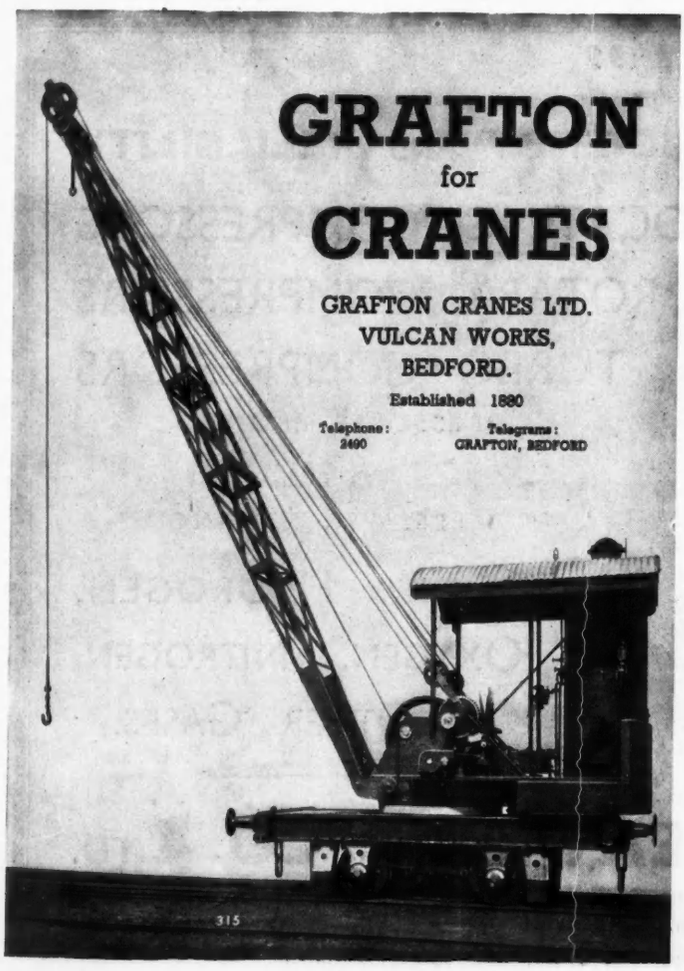

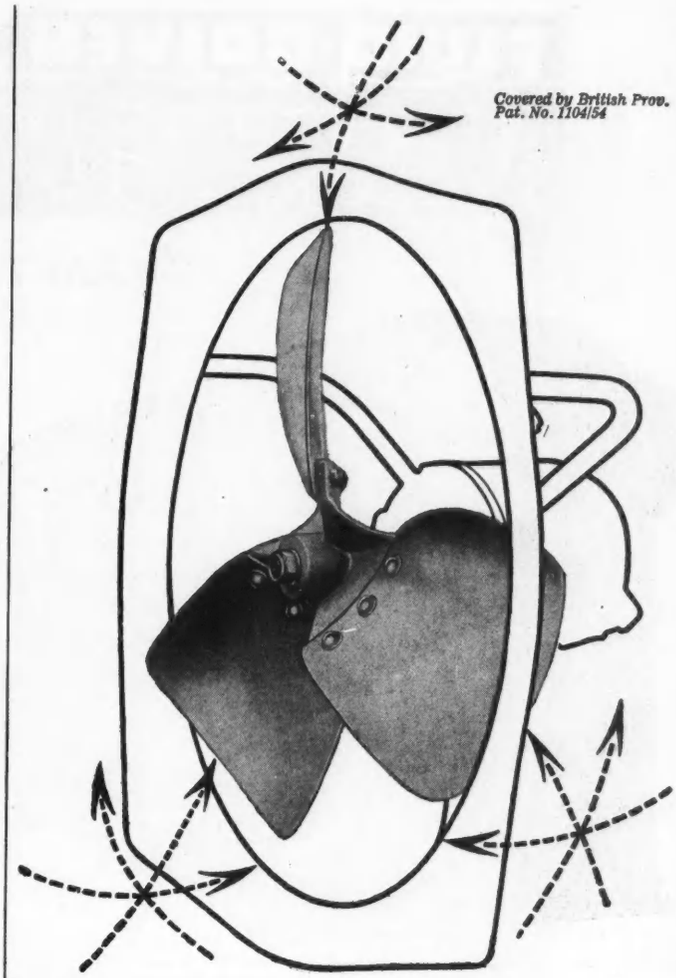

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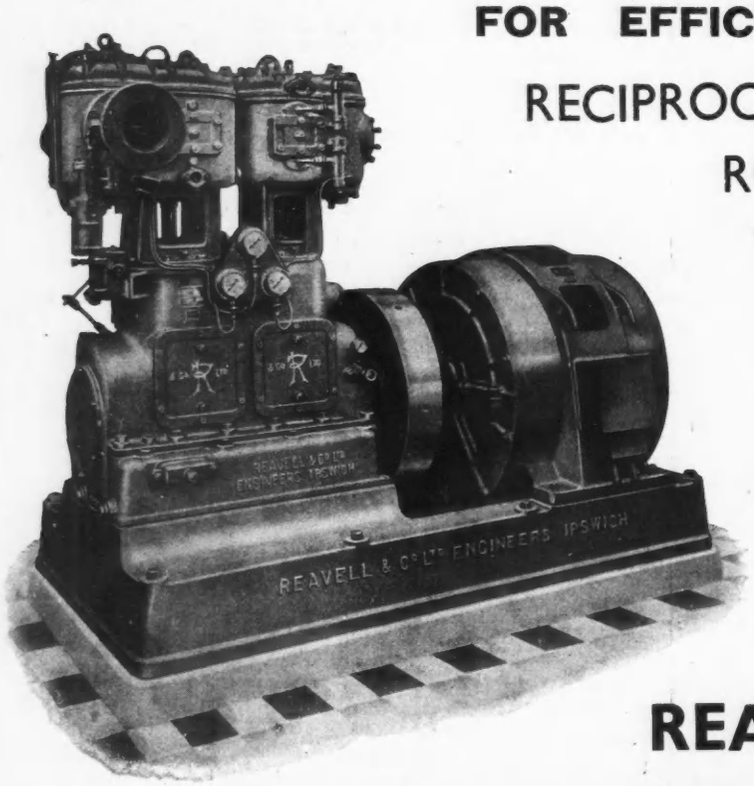

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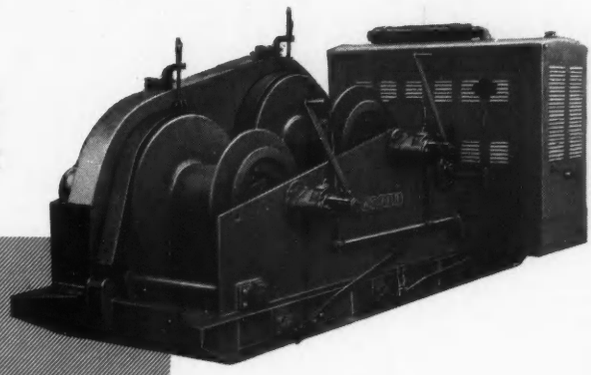
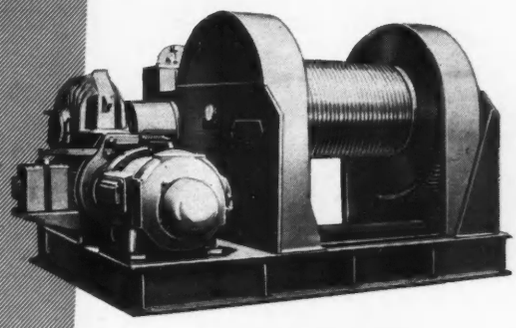
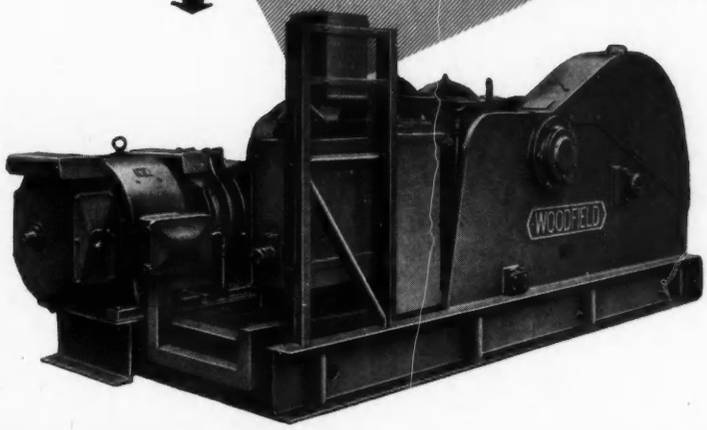


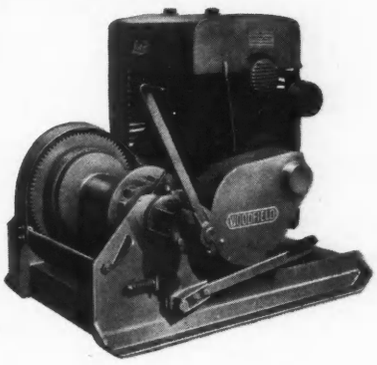
Woodfield electrically driven Slipway Winches. 58 H.P. motor geared to give 14.5 tons line pull.



Woodfield special purpose winches for raising and lowering marine mineral boring tower. Driven by 45 H.P. electric motor, these winches have a line pull of 30 tons.



Woodfield diesel driven single drum hoists. Capacity 20 cwts., for general purposes.



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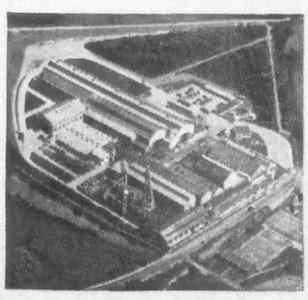

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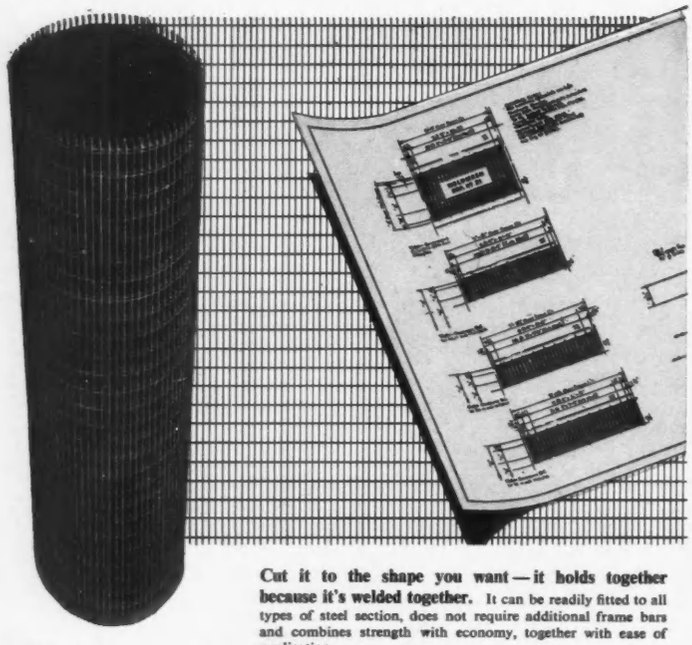

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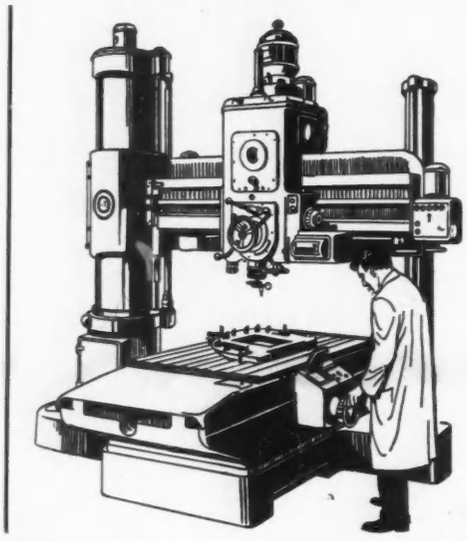

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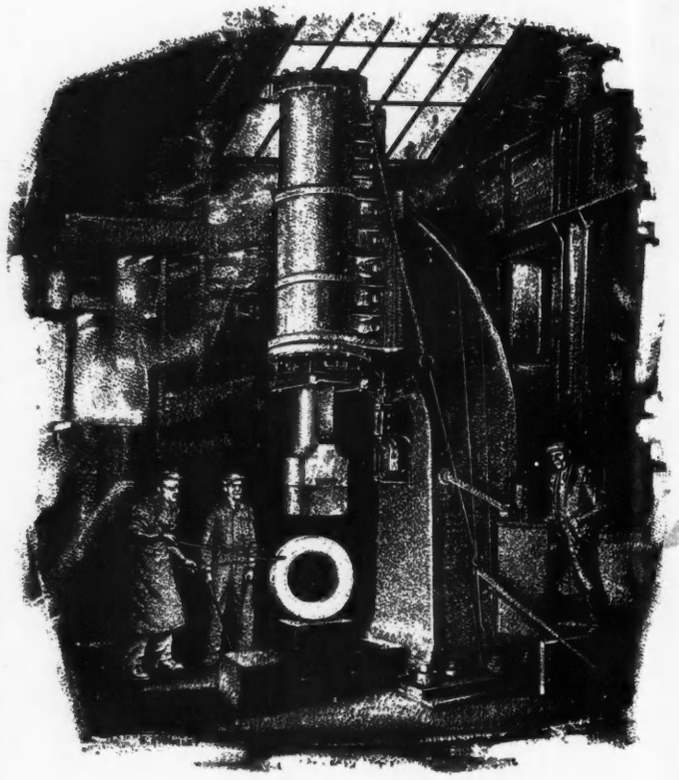

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GIVES YOU THESE 6 ADVANTAGES

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Both proprietary castable mixes† — incorporating Ciment Fondu—and refractory concrete made on site show considerable savings over special firebrick shapes.

2 LOW INSTALLATION COSTS

The advantages of concrete construction are carried into furnace building. Refractory concrete completely eliminates tedious and expensive grinding and facing of bricks.

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* *Refractory Concrete is a mixture of CIMENT FONDU and crushed refractory aggregates*

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† *A list of suppliers of crushed refractory and insulating aggregates, and of manufacturers of proprietary castable mixes is available on request*

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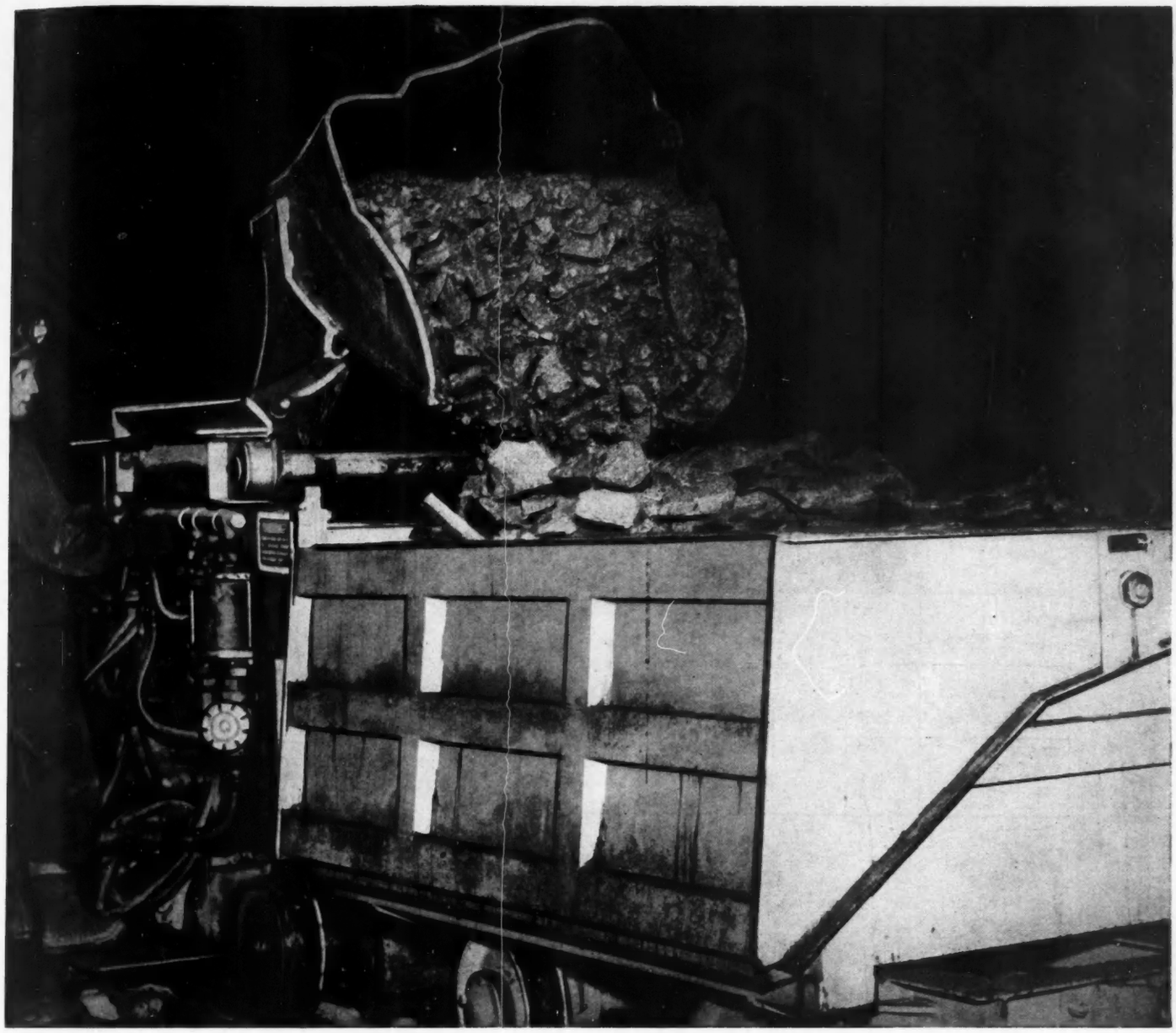

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Atlas Copco LM 200 Loaders are designed to do *bigger* jobs *faster*. Their mucking capacity, proved under actual working conditions in various parts of the world, is up to 80 cu. yds. an hour (effective loading time) for rock of big fragmentation and 130 cu. yds. for gravel and smaller stones. Wider working width and quick bucket action, larger bucket capacity and simpler operation can cut down working time by as much as a fifth. And operator fatigue is greatly reduced by the pneumatic centering and swinging mechanism.

Other types in the Atlas Copco range are the LM 100 and LM 30, which will dispose of 60 cu. yds. and 30 cu. yds. (rock of big fragmentation) per hour respectively. All types of Atlas Copco Loaders are completely enclosed and robustly built to withstand very heavy duties on underground or surface work.

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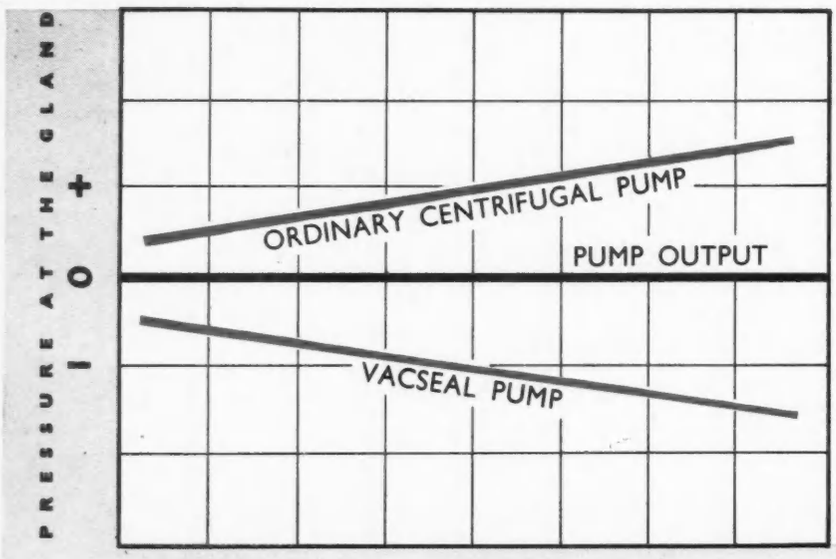

When the Vacseal Pump is operating, pressure on the gland is **below** *atmospheric pressure — there is* **no** *pressure build-up with increase of speed, as in conventional centrifugal pumps.*

Non-stop, trouble-free pumping of semi-solids, acids, and other corrosive or abrasive materials is just routine with the rugged Vacseal pump. It requires no sealing water, yet its advanced design eliminates all possibility of leakage at the gland . . . In fact, the harder the Vacseal works the better it seals! Materials being pumped are never in contact with the packing or the shaft sleeve while operating and the gland is always under suction—thus preventing ingress of solids and greatly reducing shaft wear.

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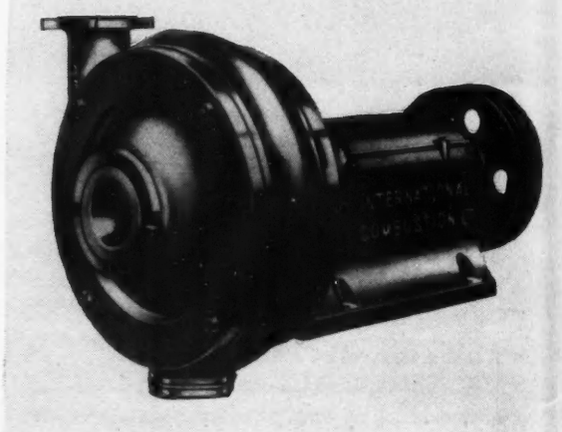
VACSEAL PUMP

The more it pumps the better it seals!



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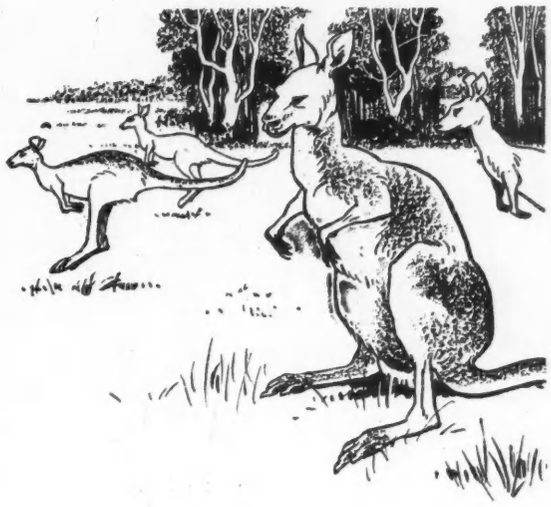

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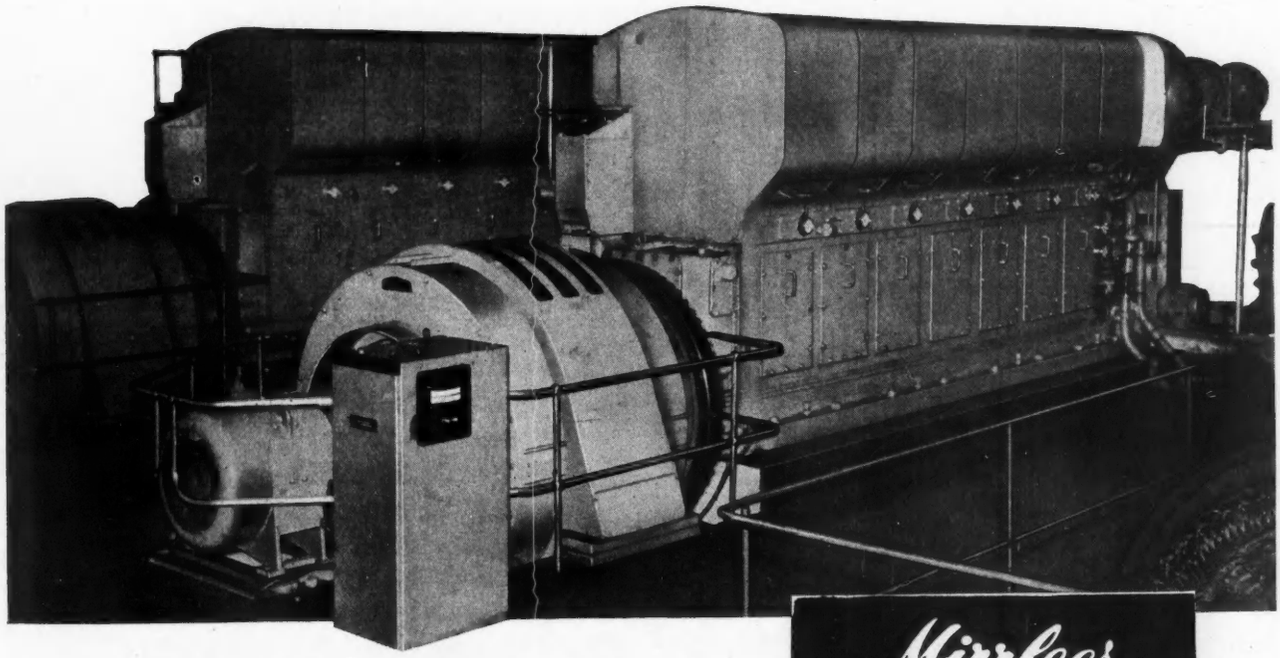

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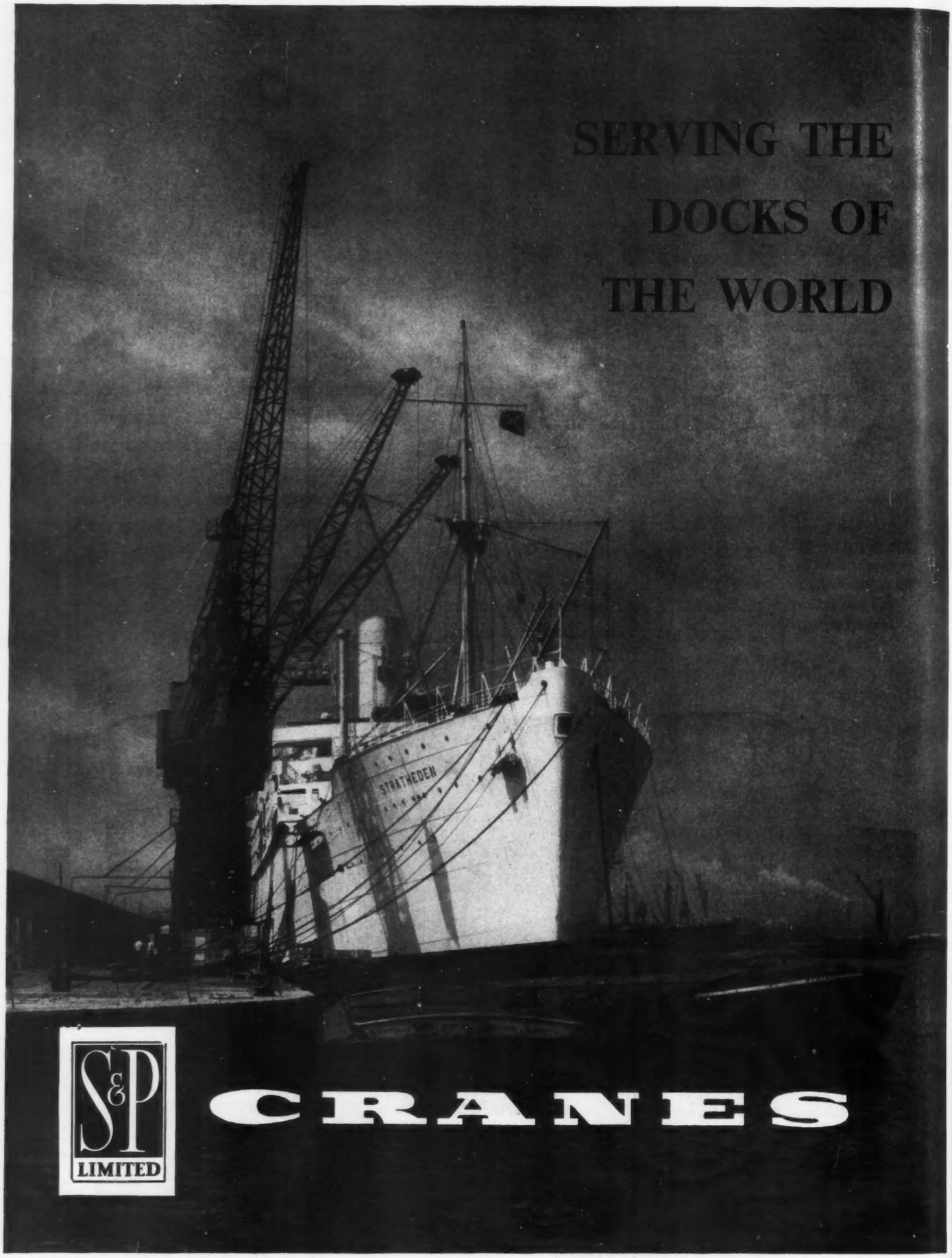

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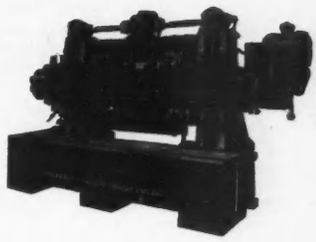
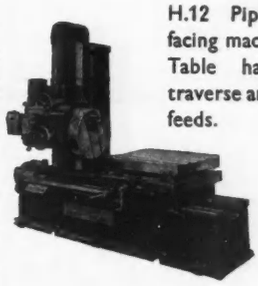


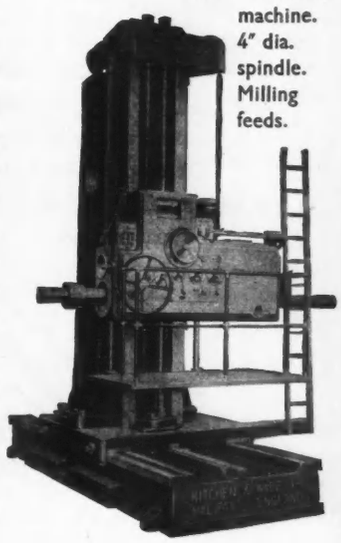
L.7 In line multiple spindle machine with automatic cycle.

E.24 4ft. to 6ft. Radial Drill. 3" Capacity. 12 speeds, 9 feeds, by single lever.



H.12 Pipe flange facing machine. Table has rapid traverse and power feeds.

H.6 Horizontal machine. 4" dia. spindle. Milling feeds.



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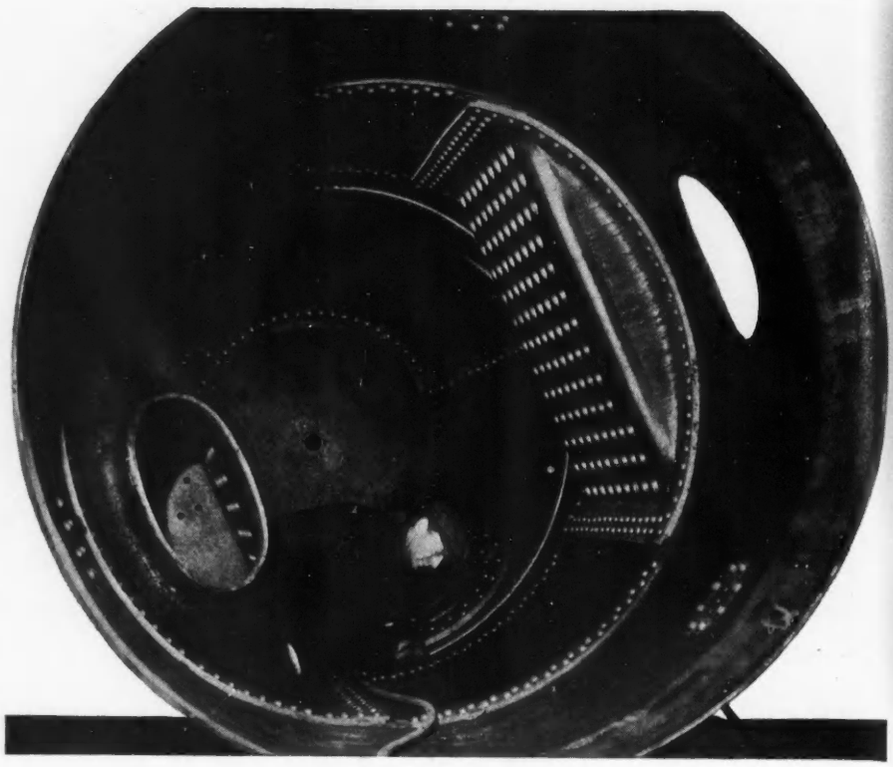
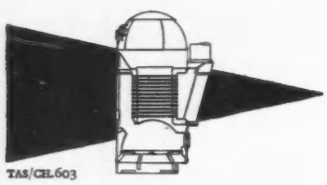
When the boiler Shell has been riveted, it is laid on its side on rolls: all plate corners are rounded off, thus allowing internal seams to be caulked continuously with a pneumatic hammer. No caulking is permitted on the external seams which are fullered with a broad tool. All rivet heads are examined carefully at this stage, and later, during the hydraulic inspection, test Caulkers examine every seam and rivet head to ensure that there are no leaks however slight. The above illustration shows a pneumatic Caulker working on an internal seam.





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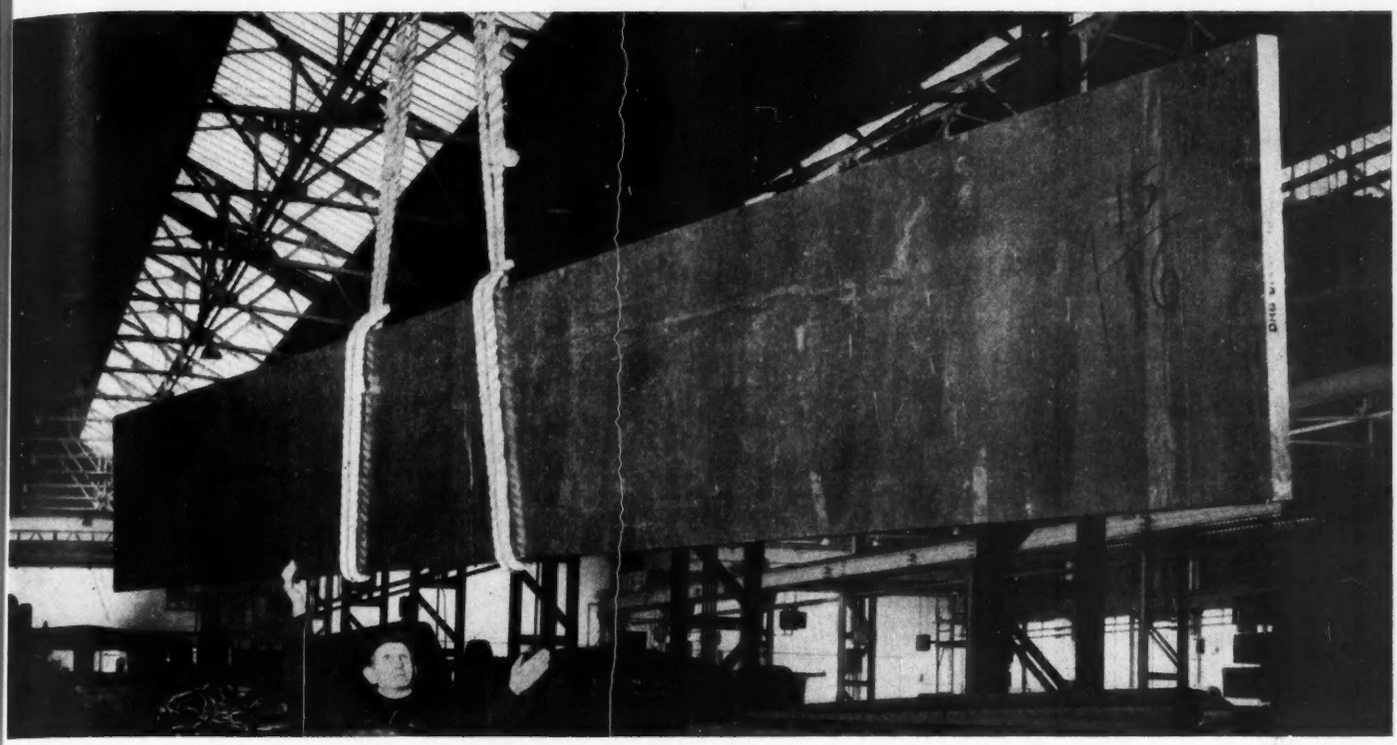


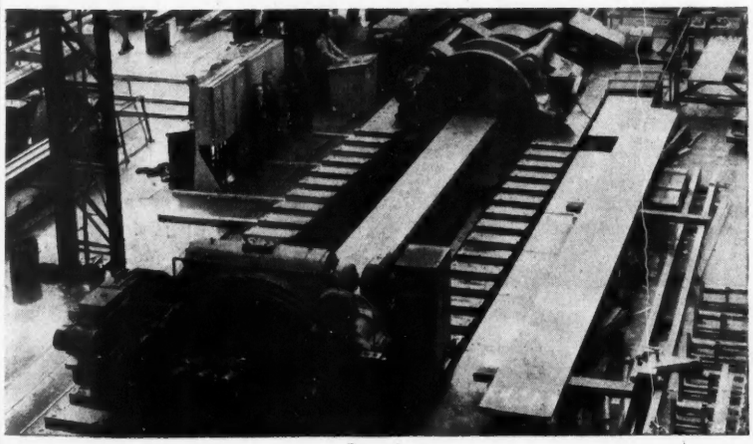
35 Feet at a controlled stretch in

DURALUMIN

REGD. TRADE MARK

This controlled stretched 'Duralumin' plate recently supplied to a British aircraft constructor by James Booth is believed to be the largest ever produced or used in this country. It is 25 ft. long, 2 ft. 8 in. wide, 2 in. thick and weighs 1,880 lb. Combining both forging and rolling, the controlled stretching process ensures uniformity of mechanical properties by eliminating stresses due to heat treatment and the undesirable core effect usual with plates of this thickness. This means that components can be machined from thick plates without suffering subsequent distortion. Ultrasonic testing at the casting and the final stage ensures that plates are free from internal flaws.

The stretching process in operation.



Plates produced by this process conform to D.T.D. specifications 5010, 5020, or 5050. Even larger plates—up to 35 ft. long—can be supplied provided the cross sectional area does not exceed 65 sq. in.

Please write for further details.

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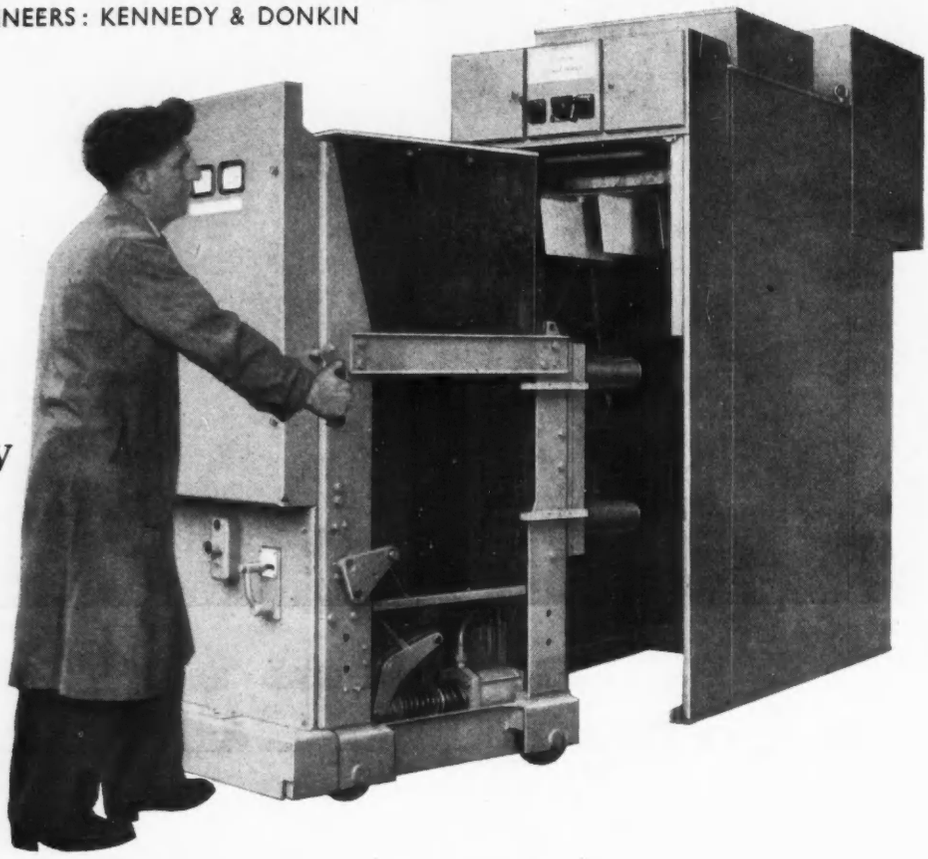

The first 11-kV equipment incorporating an air-break circuit-breaker has been ASTA tested for a rating of 500 MVA.

A number of these equipments are being installed in the North of Scotland Hydro-Electric Board's St. Fillans power-station.

11-kV
500-MVA
AIR-BREAK
SWITCHGEAR

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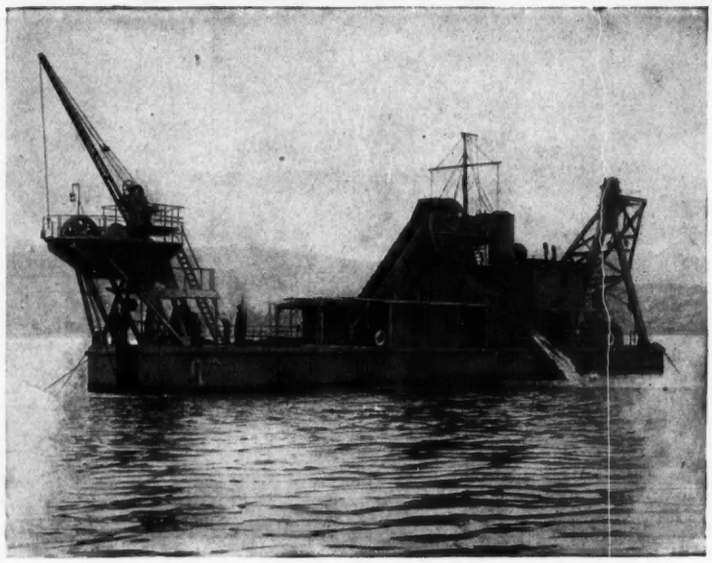
A. REYROLLE & COMPANY LIMITED HEBBURN · COUNTY DURHAM · ENGLAND



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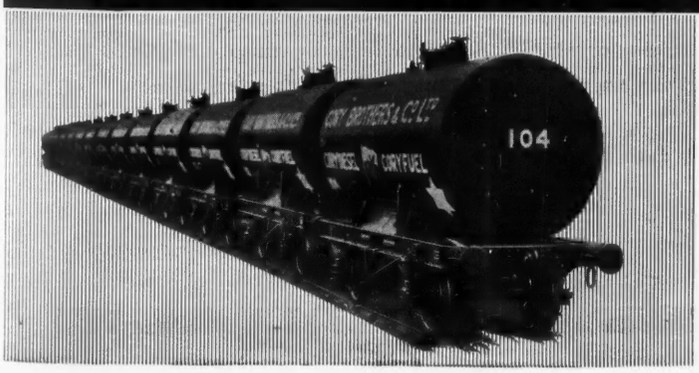

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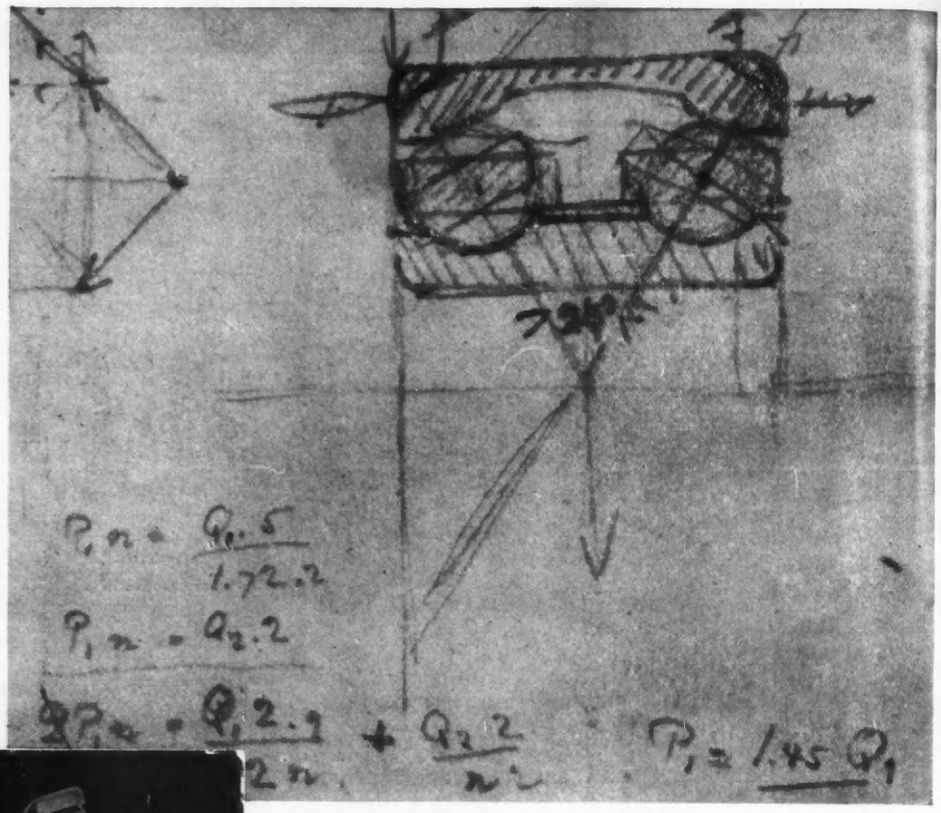
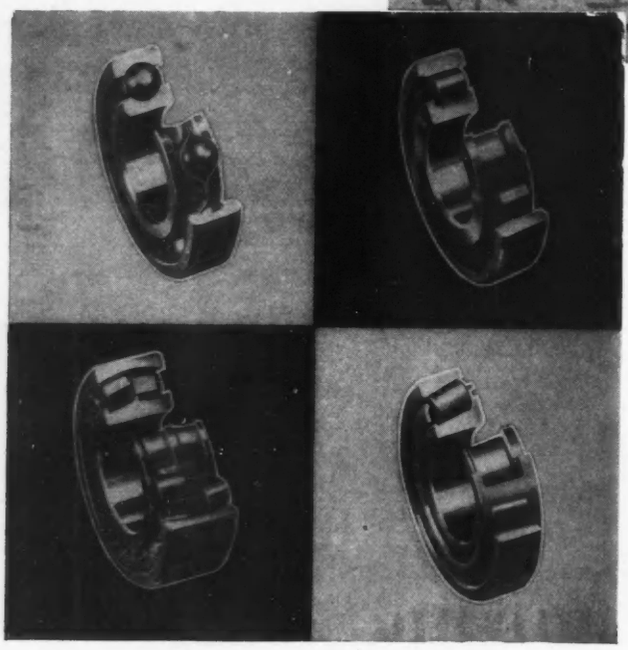


A reproduction of the first rough sketch of the double row self-aligning ball bearing, invented by Dr. Sven Wingquist the founder of **SKF**.



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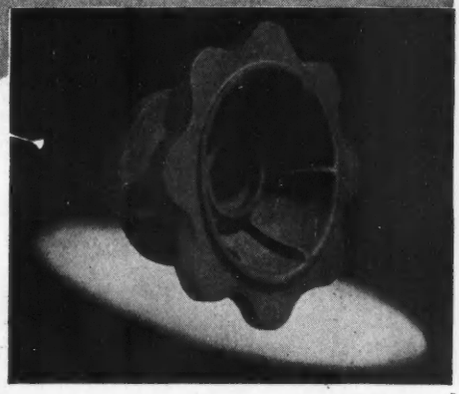

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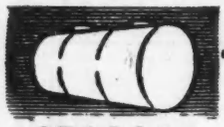

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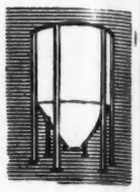

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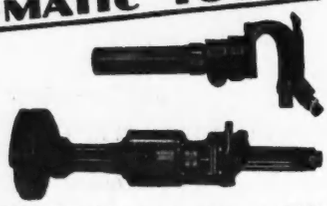

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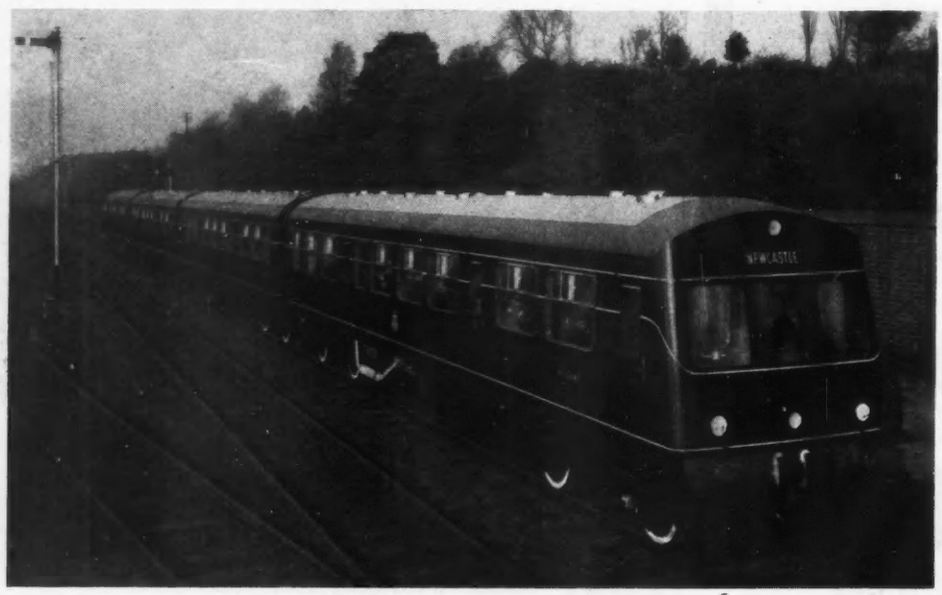

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for British Railways Modernisation Plan already supplied by

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The illustration shows a four-car Unit comprising 2 Motor and 2 Trailer Cars for the Newcastle-Carlisle service. The total of 571 Cars ordered from METRO-CAMMELL includes a number of Twin, Triple and 6-car Units.

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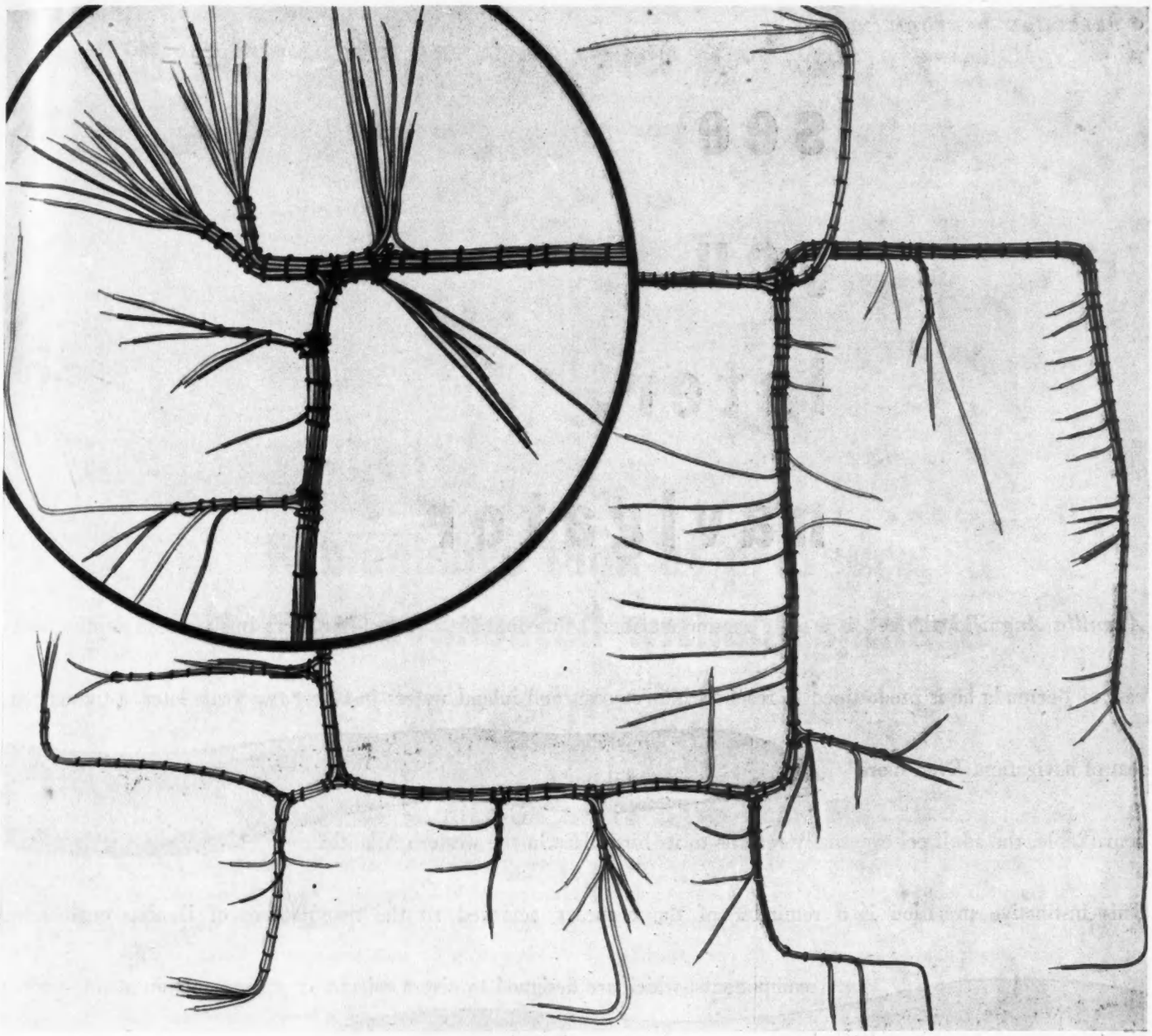

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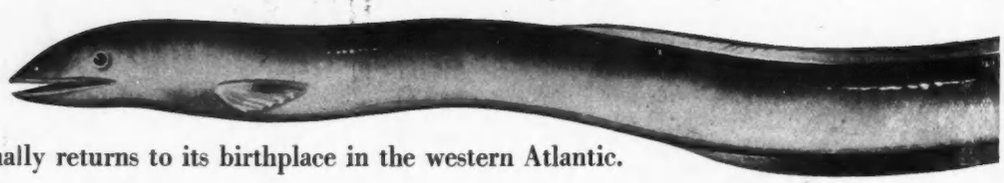
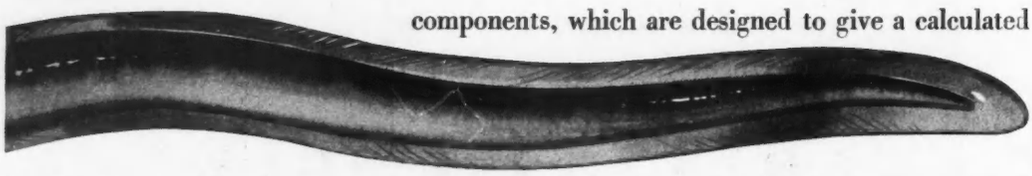
see you later, navigator

Anguilla Anguilla, the eel, is a real "master mariner". Starting life as a leaf-like larva in the ocean depths south-east of Bermuda he is predestined to reach Britain's coasts and inland waters just over two years later, a tremendous feat of navigation. Even more



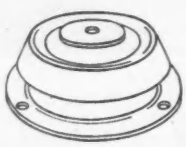
remarkable, the adult eel eventually returns to its birthplace in the western Atlantic.

This instinctive precision is a reminder of the accuracy achieved in the manufacture of Dunlop engineering components, which are designed to give a calculated performance in a wide variety of industrial applications.



Produced in rubber compounds of controlled elasticity or rigidity, they include bonded-to-metal anti-vibration mountings and flexible power-transmission couplings which are available in standard ranges. Special components in natural and synthetic rubbers can also be

produced to a given specification. Consult Dunlop Engineering Components Division on problems of this kind.



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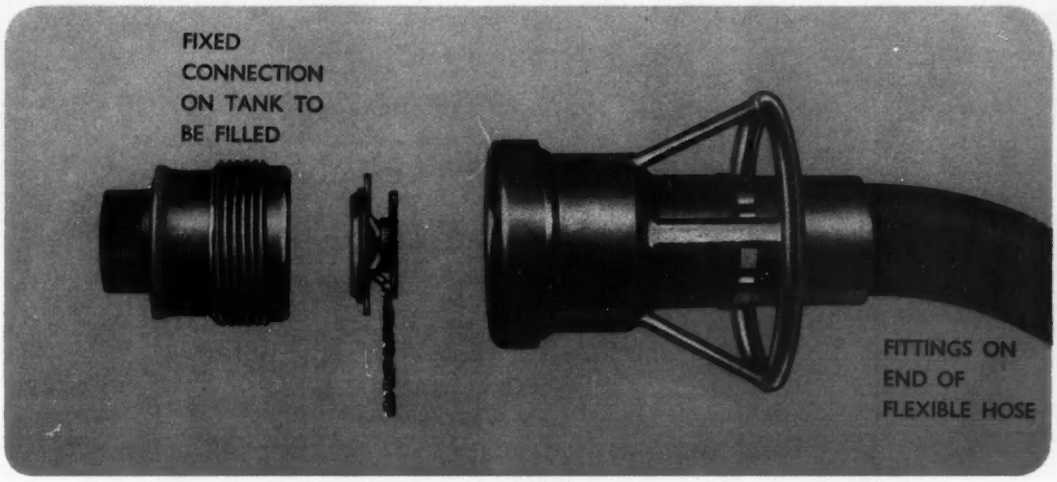

Replenishes tank at pressure, is then connected without spillage

both fittings are self-sealing

MORE THAN A MILLION UNITS HAVE BEEN SUPPLIED

These couplings are self-sealing directly the couplings are disconnected; there is no spillage of the contents of the hose and no entrapping of air. The hoses are made in various qualities and sizes, some are available for very high pressure, fireproof when required, and they lend themselves to a great many applications for air and gases under pressure, for oil, fuel and hydraulic fluid.

They have been standardized for British Railways for refuelling diesel locomotives. Used in this way the couplings give the most efficient form of refuelling, being connected and disconnected in a fraction of a minute; there is no need to upend the hose and there is no loss of fuel.

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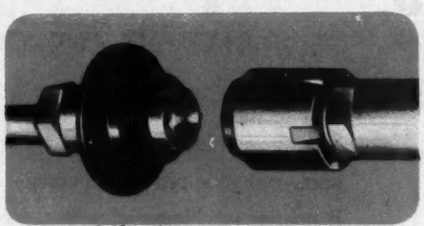

Self-sealing coupling detached from flange-type mating piece

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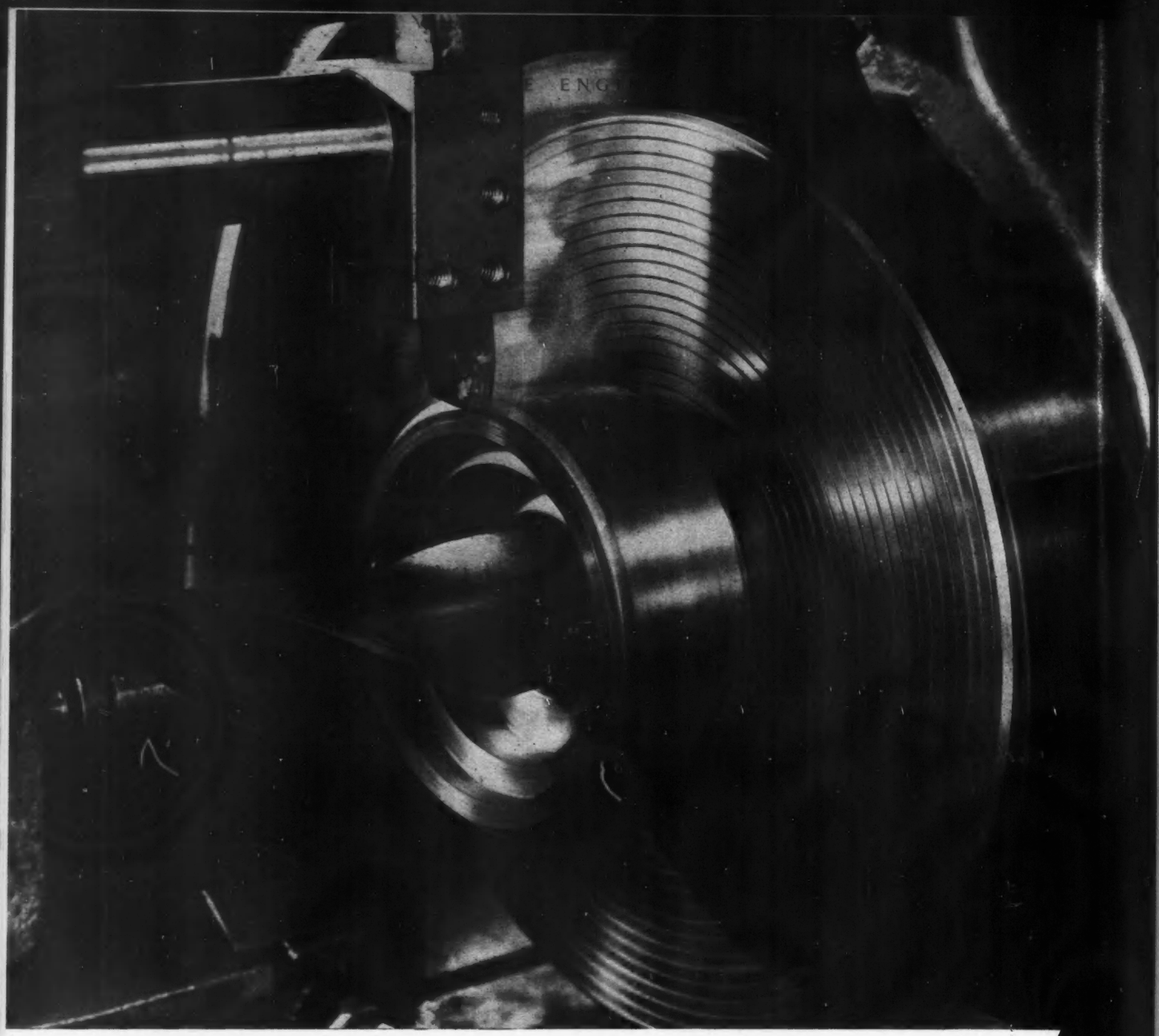

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Illustration: Machining the body casting of a Crawford 'Trugrip' collet chuck.

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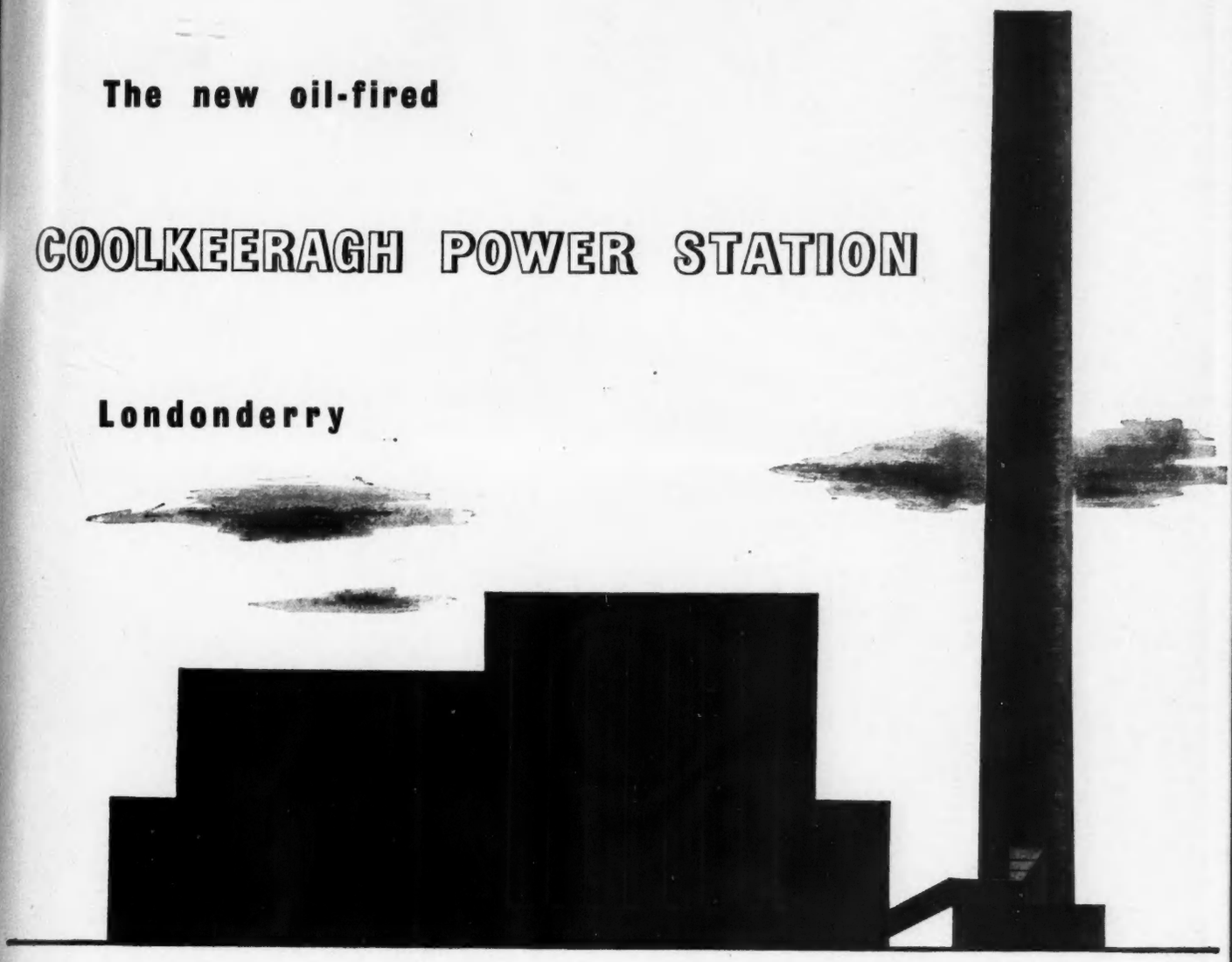

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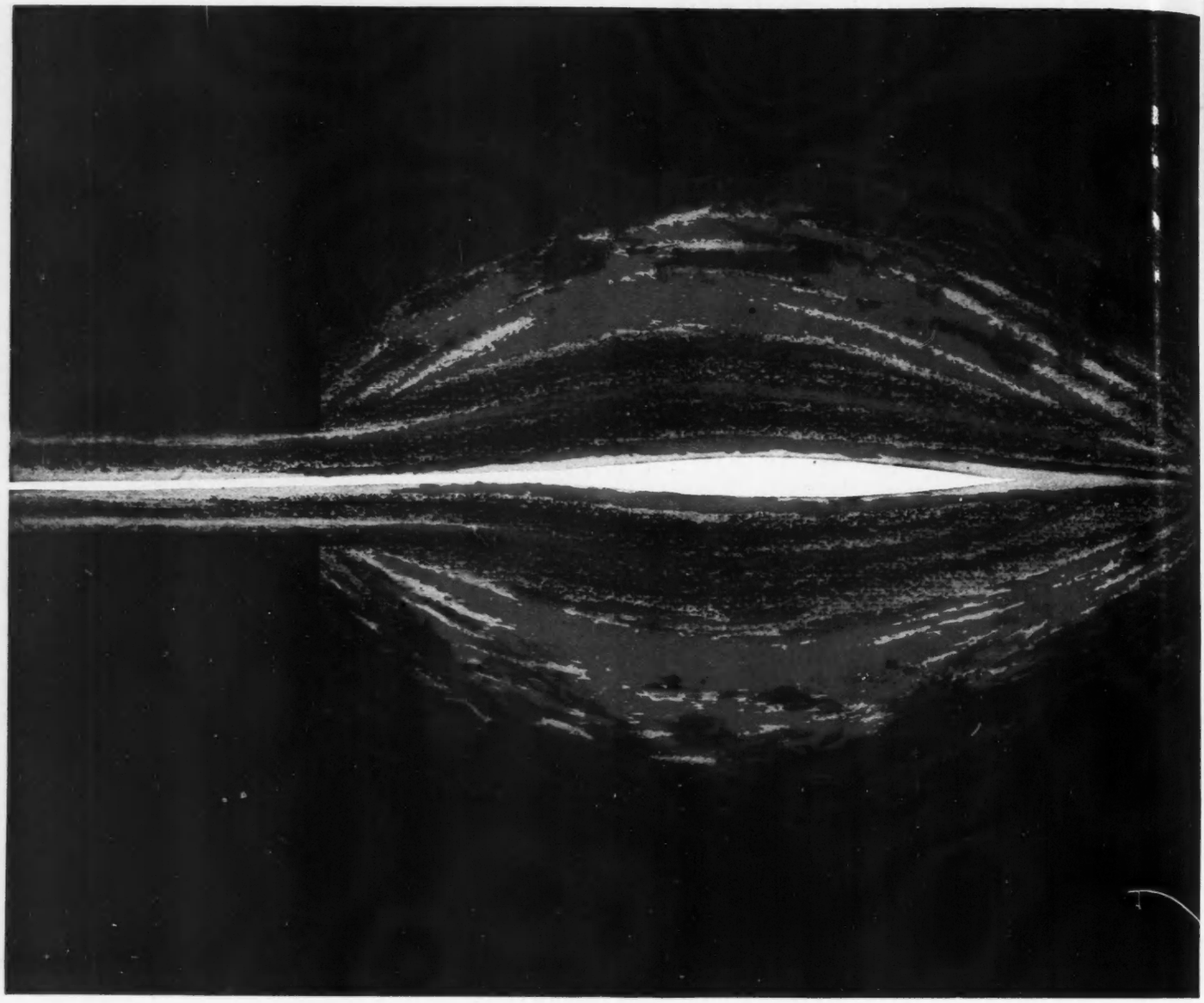

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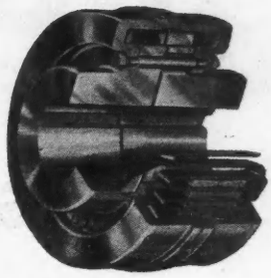

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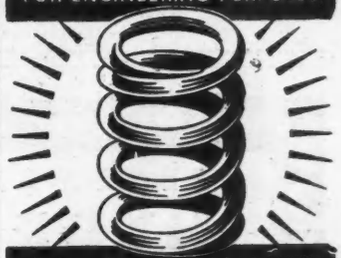

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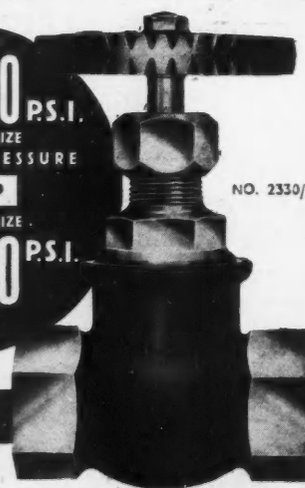

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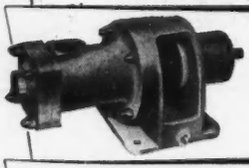

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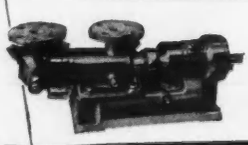

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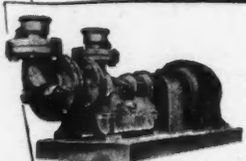

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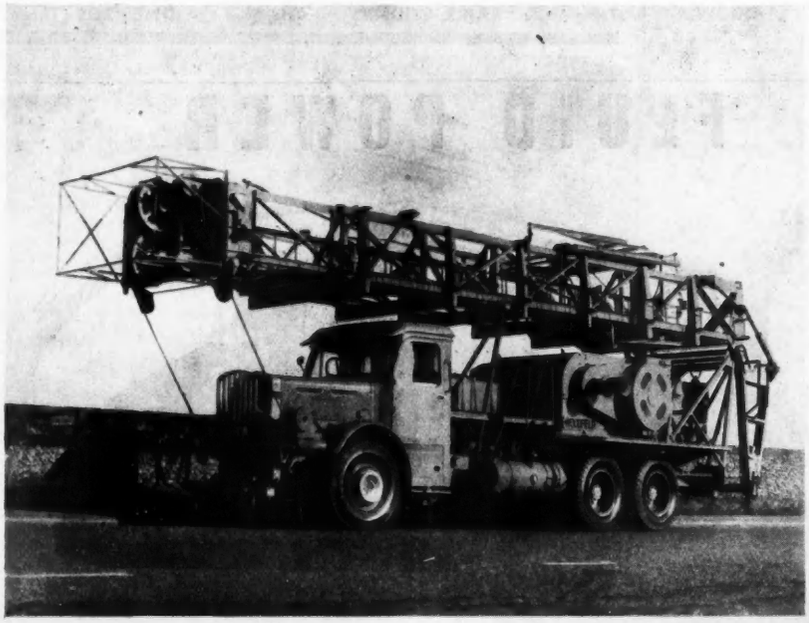

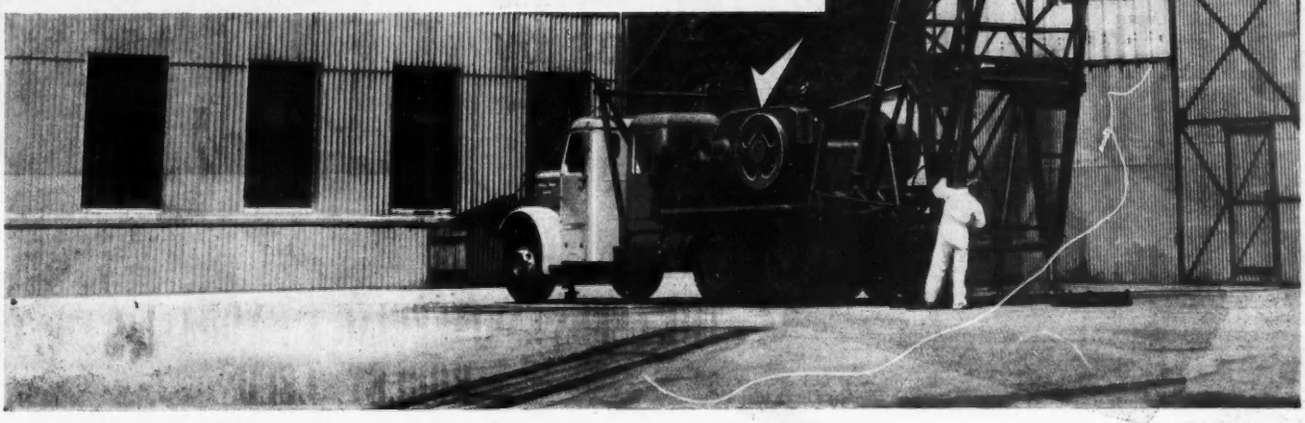

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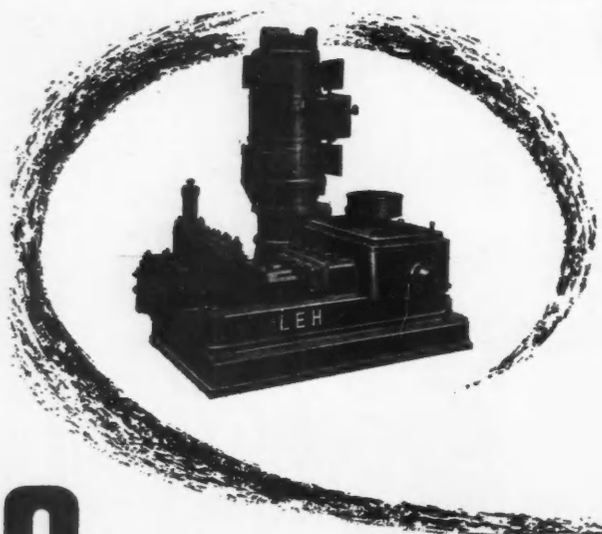

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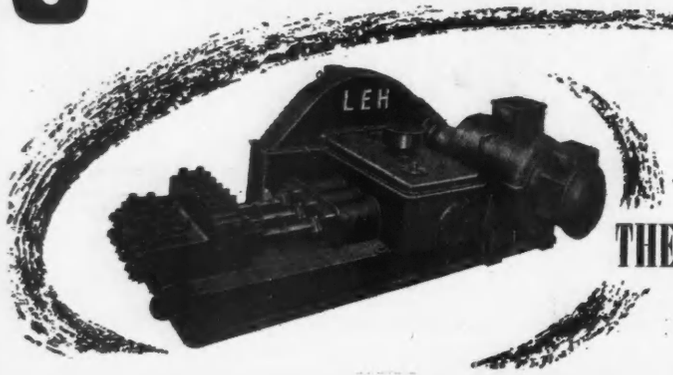

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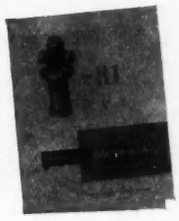

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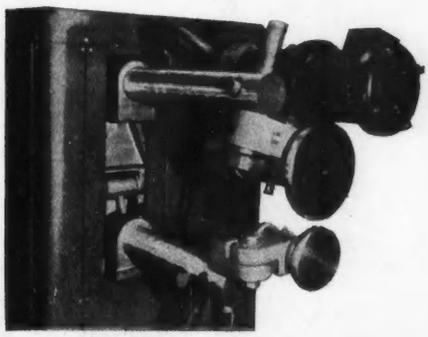

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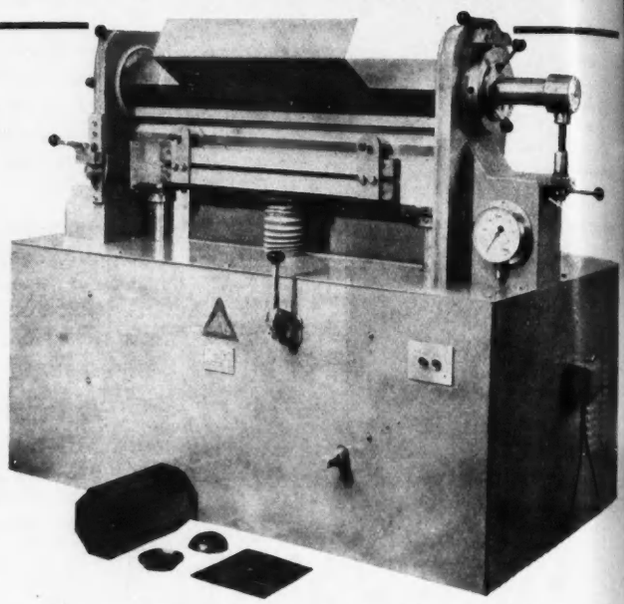

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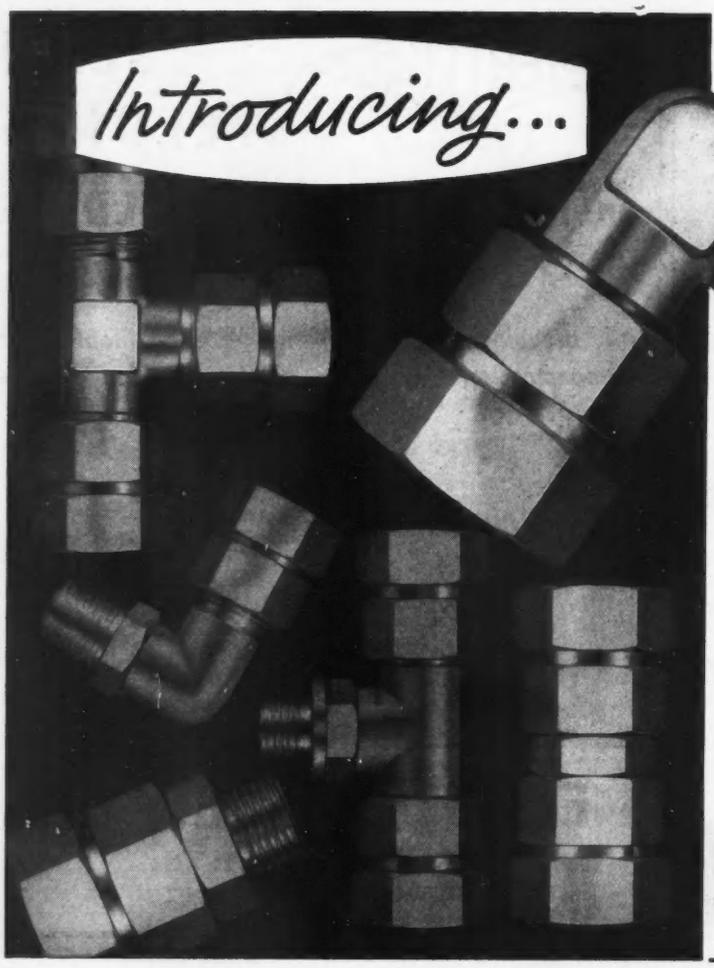

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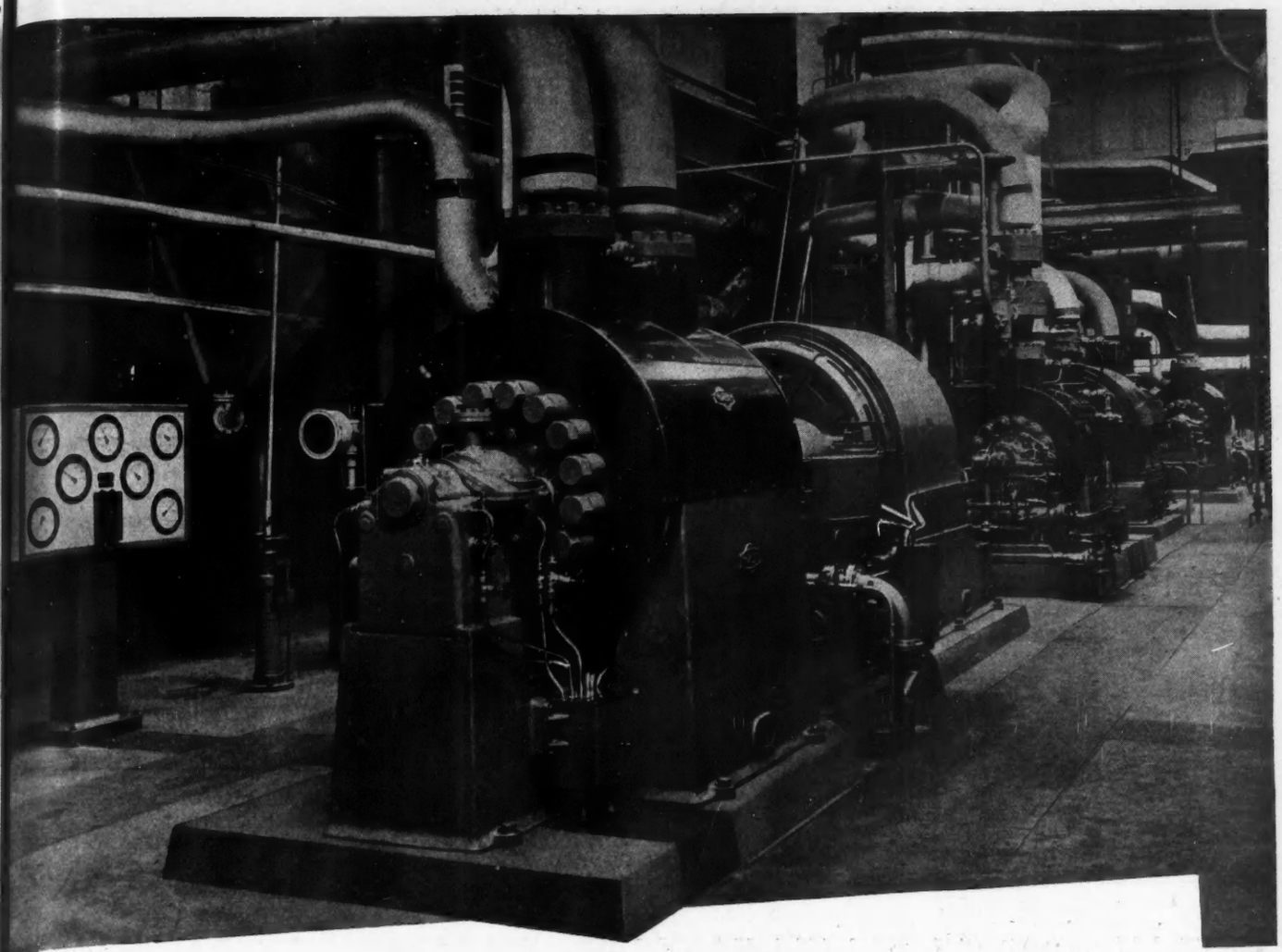

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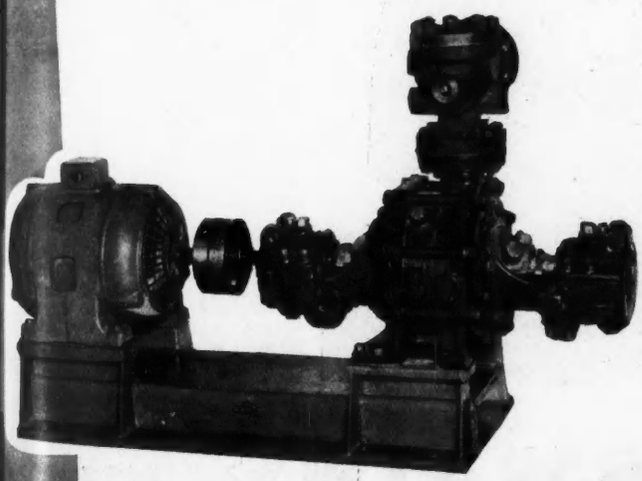

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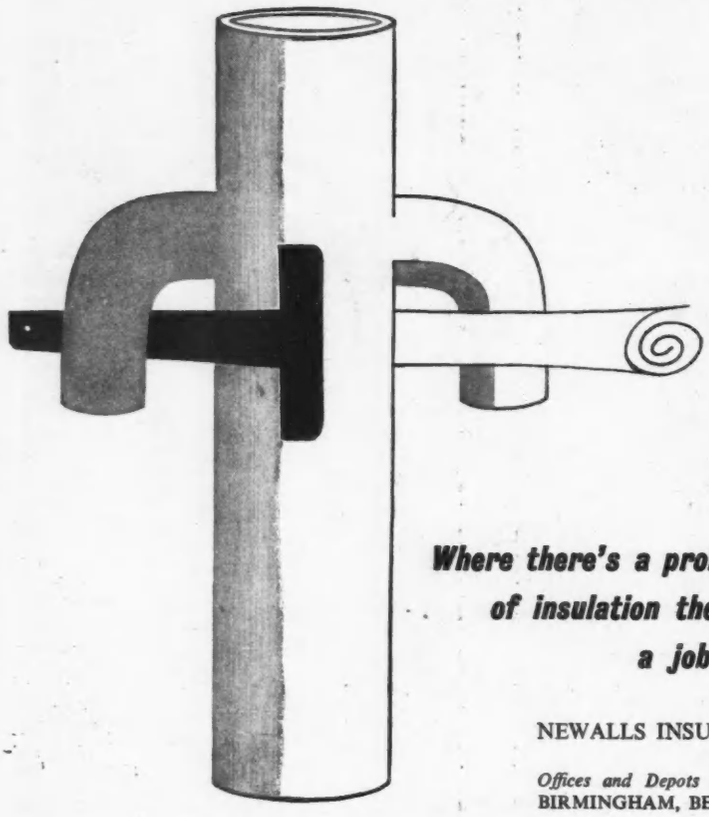

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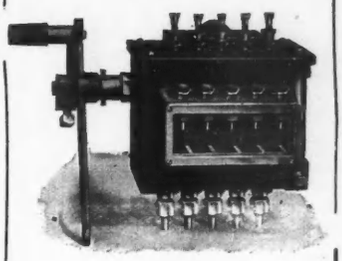

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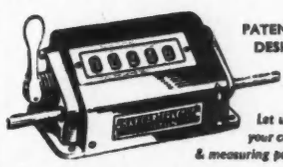

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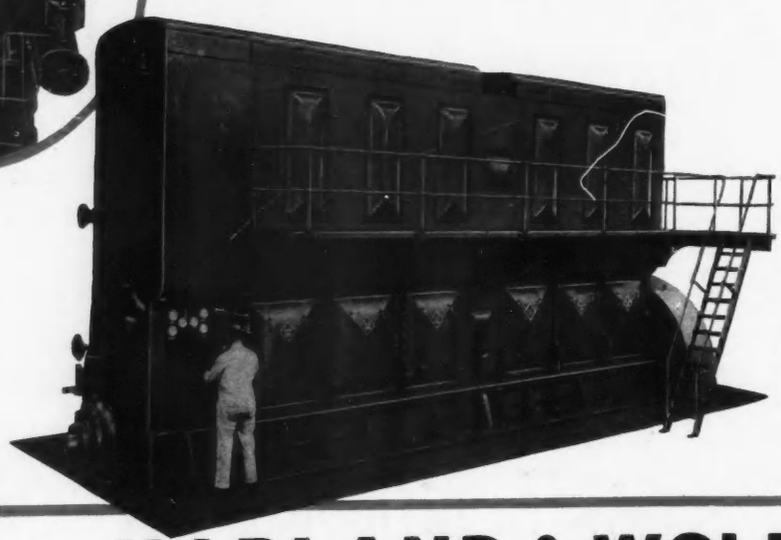

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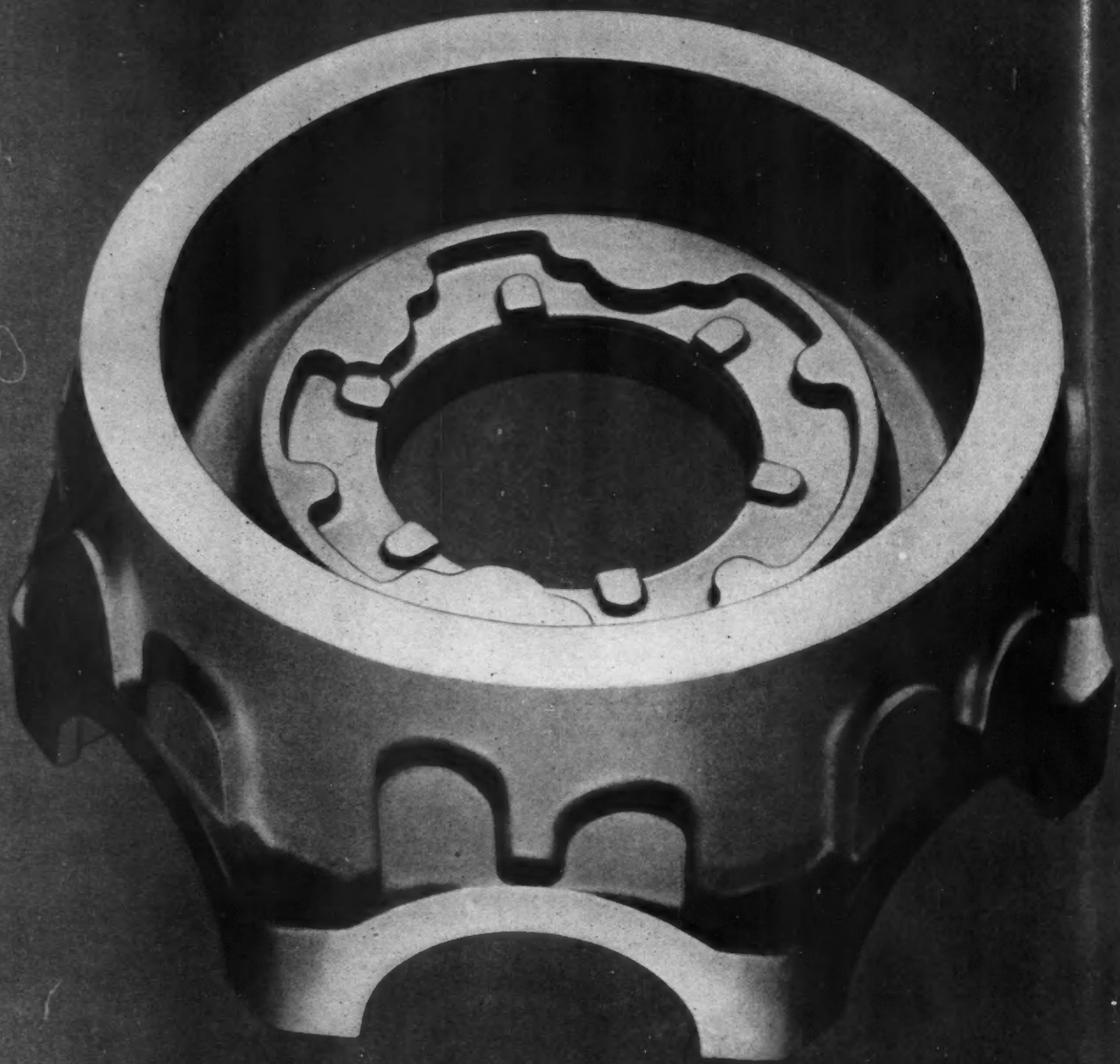

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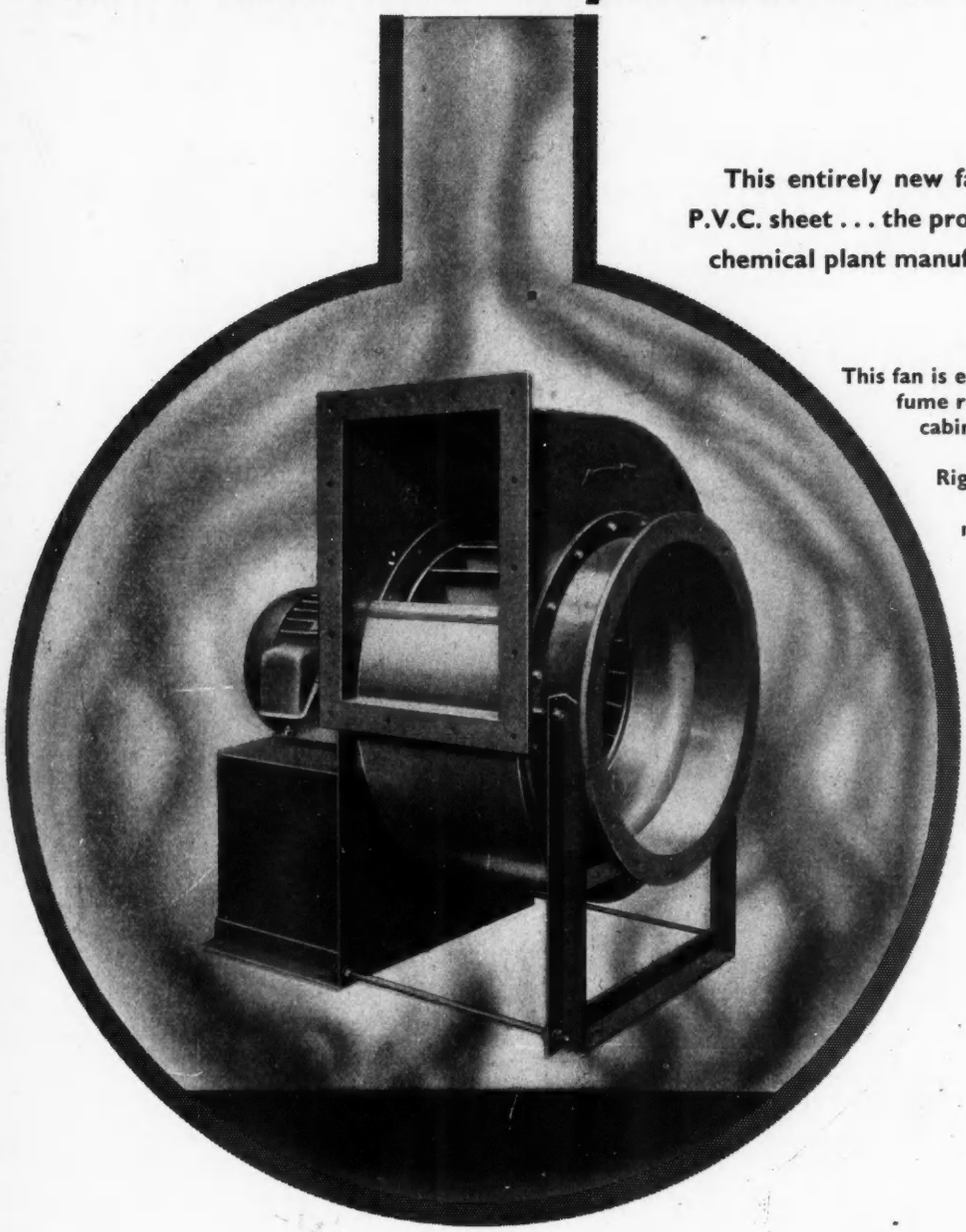

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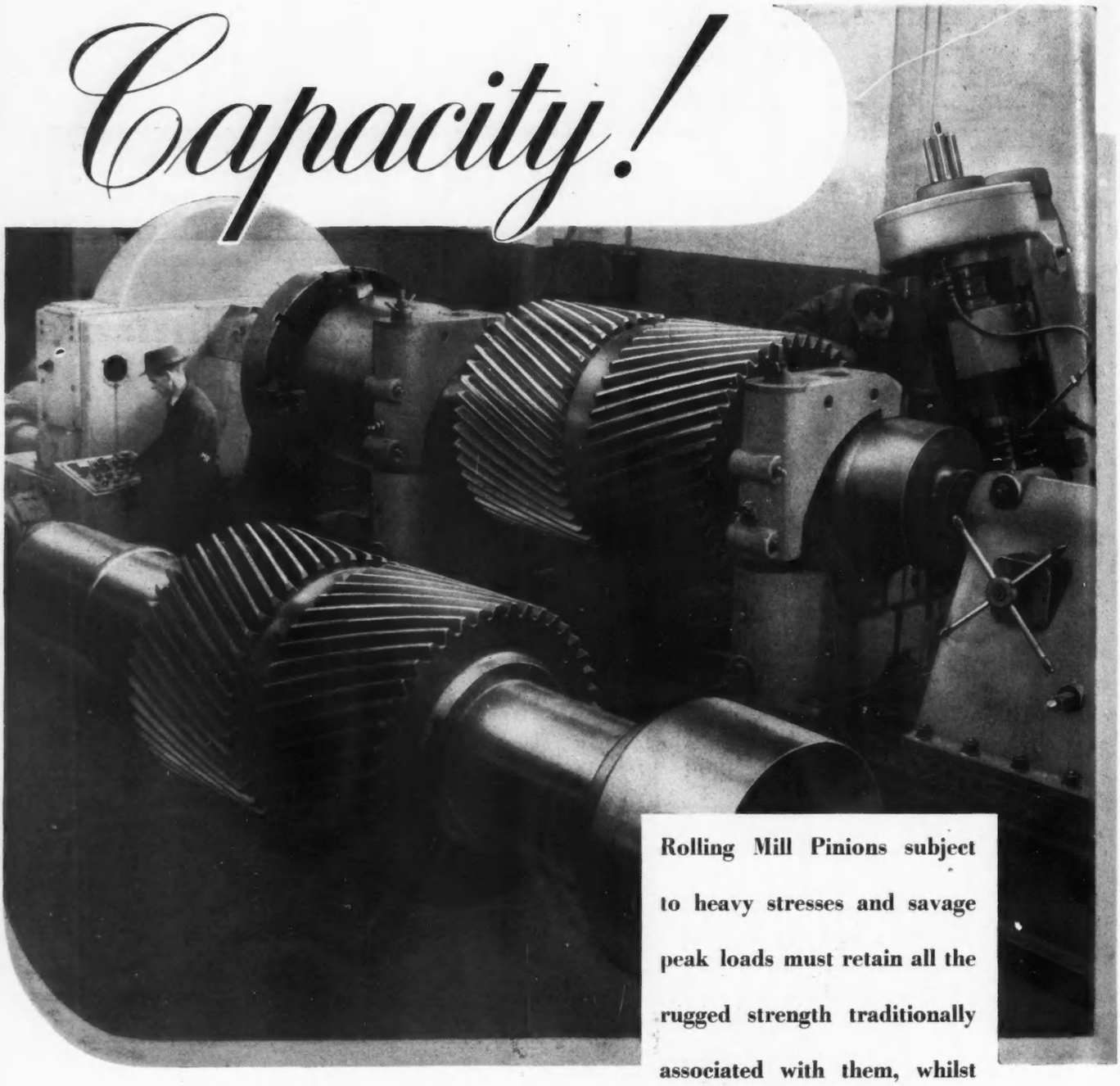

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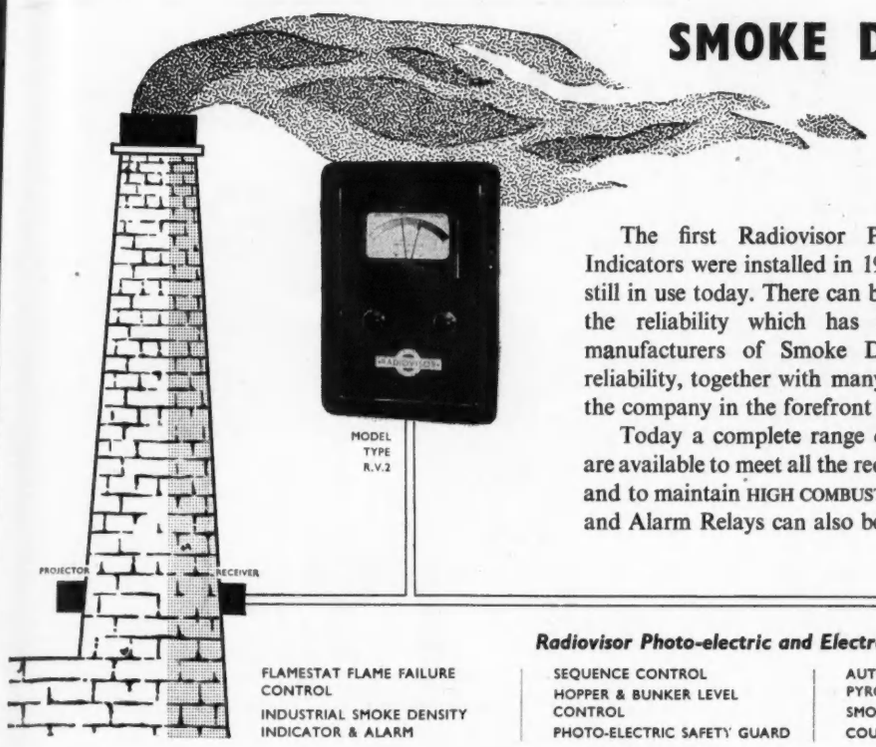

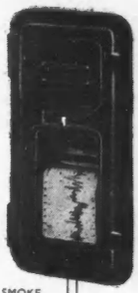

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BUDWORTH *gas turbines*

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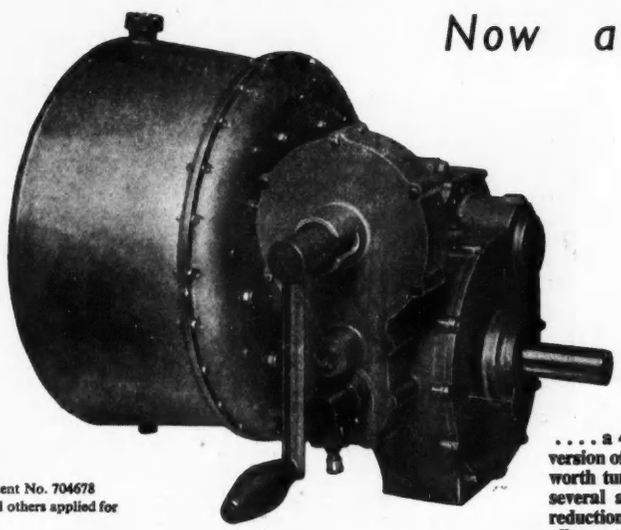

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. . . . a 45/60 h.p. version of the Budworth turbine with several alternative reduction gears for all portable and other power requirements.

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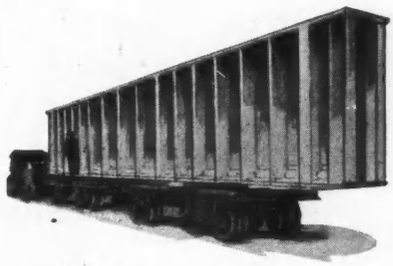

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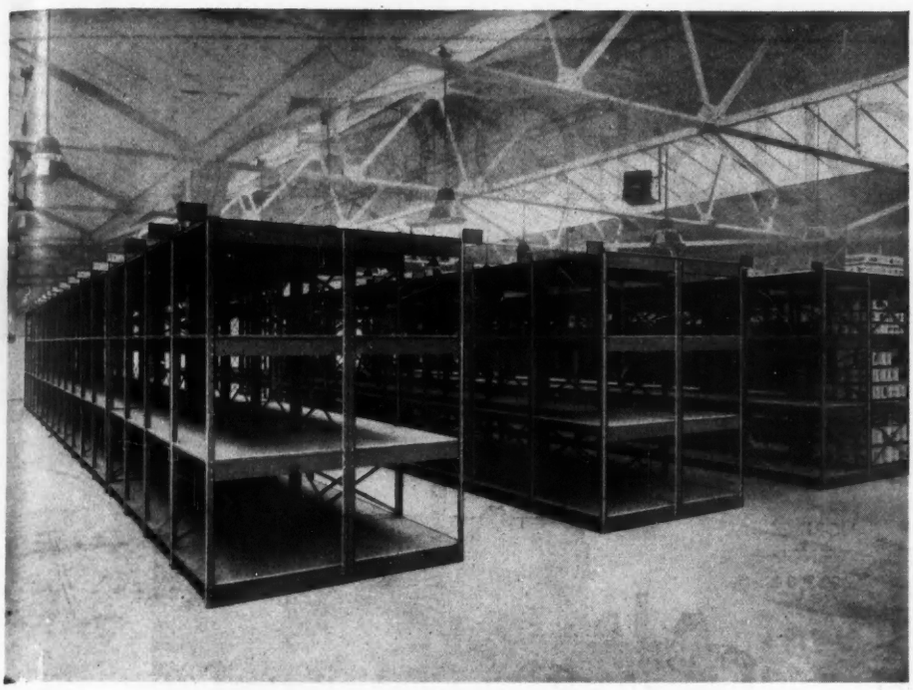

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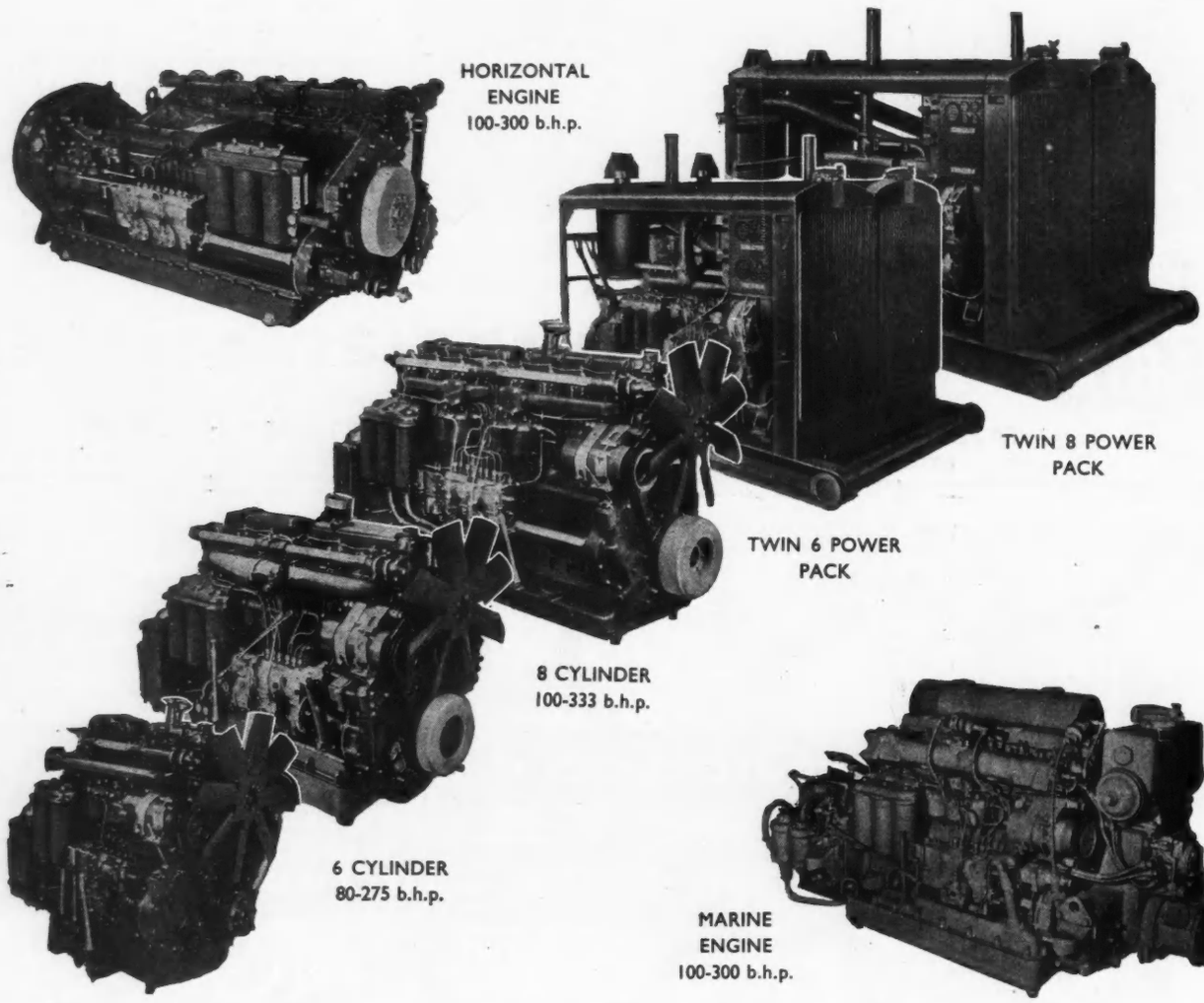

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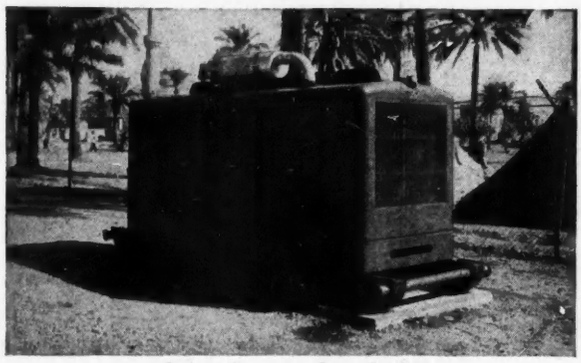
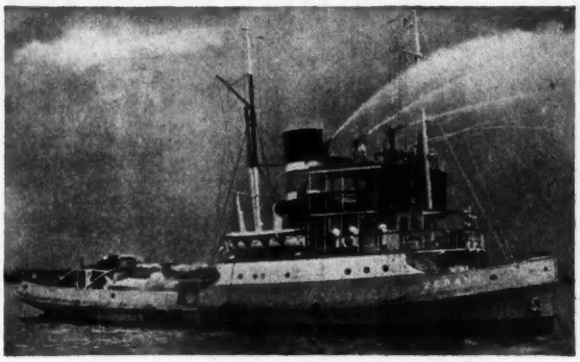
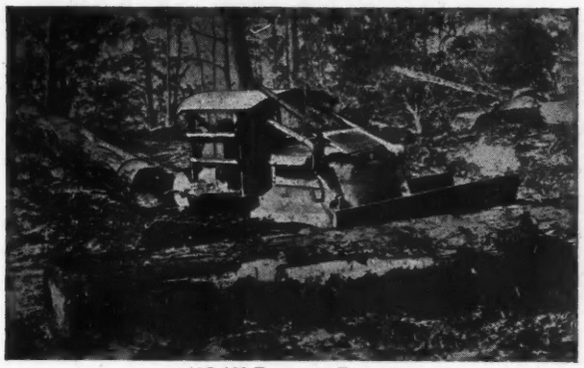


Petbow Generating Set in Baghdad

Scammell Constructor in Kuwait



Merryweather Fire Fighting Equipment in Indian Ocean



V.R.180 Tractor in Tasmania

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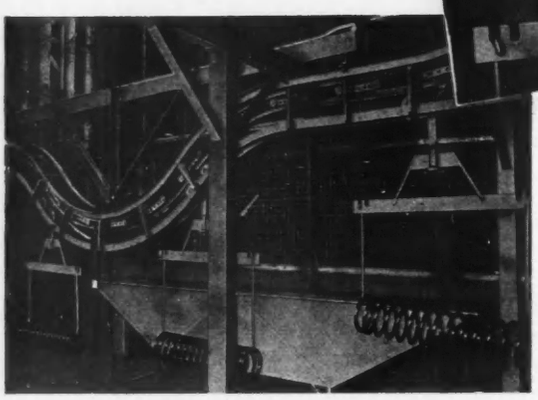

3

This is a Teleflex Chain Creeper Conveyor used for transportation through spraying and foundry processes. Each carrier is suspended from a heavy-duty trolley running in a subsidiary track which, in **Illustration 1**, is shown diverting from the driven portion of the Conveyor.

The carrier when diverted can be gravitated and traversed by hand and then pushed into the moving circuit, where it is picked up by a driving dog assembled in the link of the driving chain.

Illustration 2 shows trolley travelling towards a stoving oven. **Illustration 3** demonstrates how the Chain Creeper Conveyor is made to elevate over a comparatively short distance.

Full details of Teleflex Conveyors on request.

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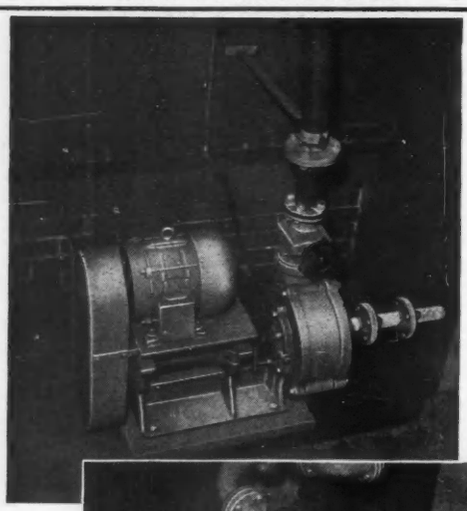

Imagine a pump that can withstand the insidious attack of having corrosive chemical fluids pumped through at the rate of thousands of gallons a day for eight years without re-servicing!

That's the Linatex pump. The secret behind this remarkable achievement is Linatex, the 95% pure natural corrosive-resisting rubber. Linatex have designed and built their pump around this wonderful material. Of three pumps installed in 1949 at the textile factory of William Hollins and Company Ltd., one required servicing after a minimum of 6,000 hours use; the other two have given trouble-free **service for eight years!** Pleased with these results, William Hollins put two more into operation in 1955. Both have given trouble-free service for 2,000 hours. Many branches of industry are now using Linatex to solve corrosion problems—a fine tribute to an outstanding material.

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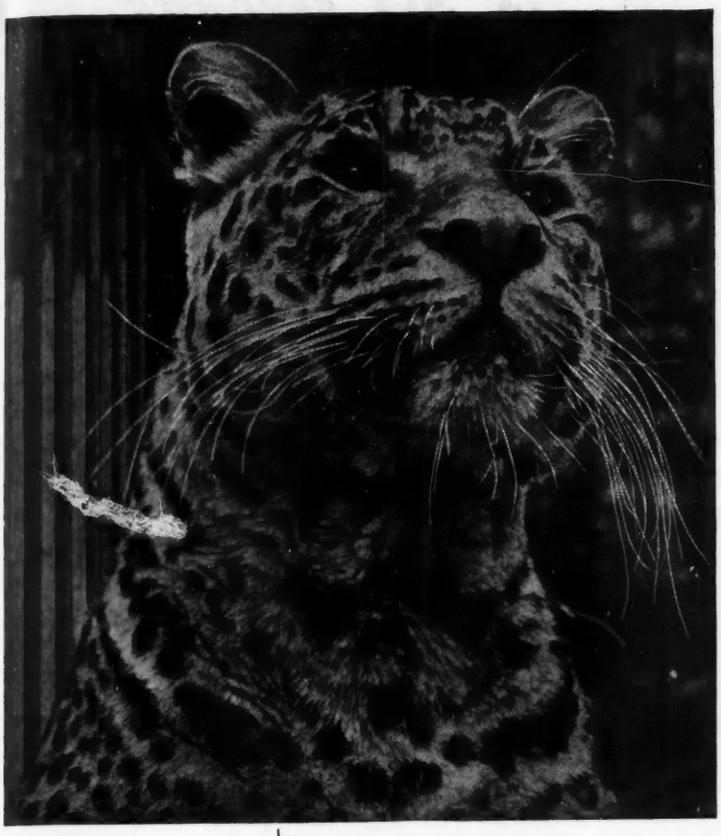

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These typical double cold bends show the remarkable ductility of Wrought Iron. Essentially fibrous in its structure, Wrought Iron possesses an exceptional toughness which gives it a high resistance to vibration and sudden shock—properties which it retains under severe cooling and heating stresses.

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The toughness of Wrought Iron is unequalled. Besides withstanding shock and overstrain, it staunchly resists rust and corrosion. Containing slag inclusions which reinforce its own susceptibility to welding, it is for many purposes both safer and more economical than mild steel as a long-term proposition—especially under exposed or wet conditions.

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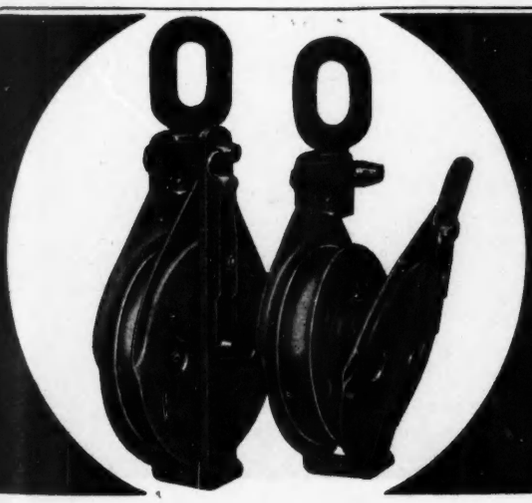

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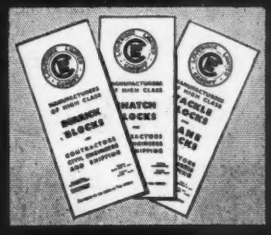

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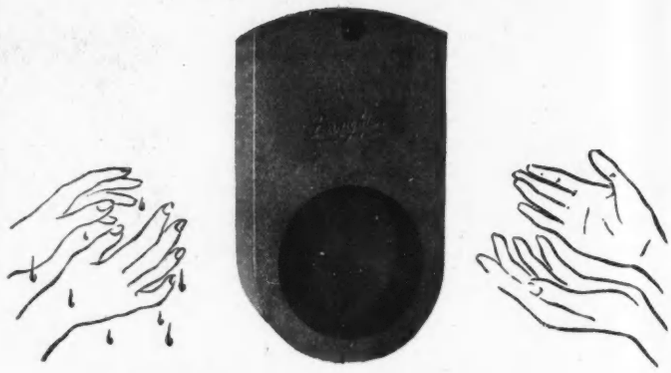

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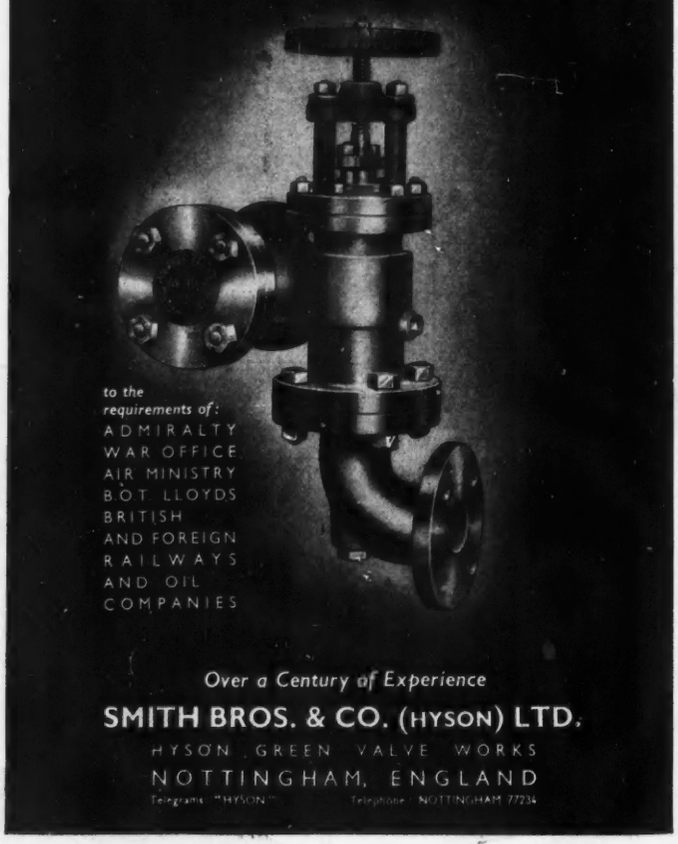

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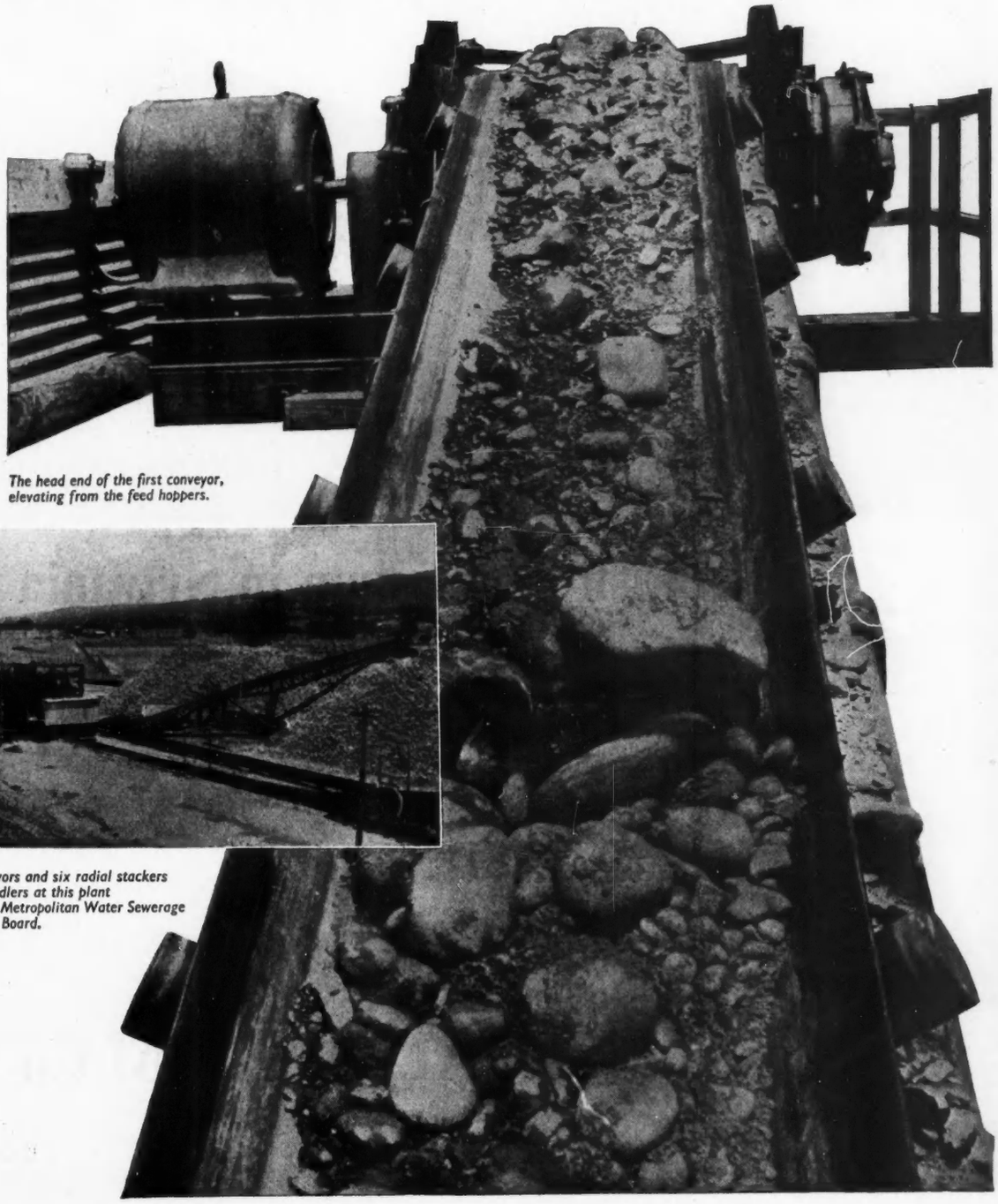
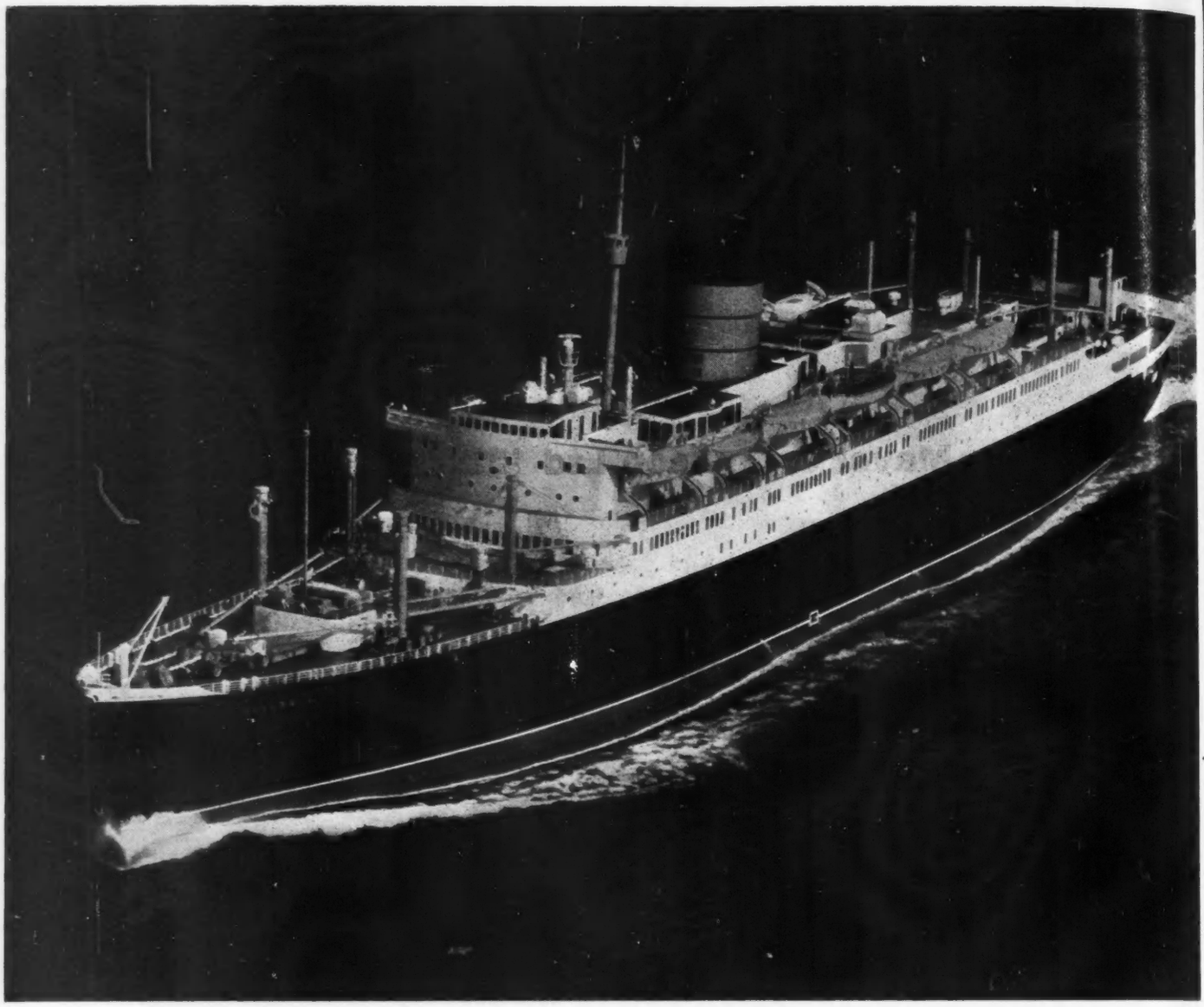


The head end of the first conveyor, elevating from the feed hoppers.

38 belt conveyors and six radial stackers run on M&C idlers at this plant of the Sydney Metropolitan Water Sewerage and Drainage Board.



British Aluminium in Sylvania

Like her three sister ships—Saxonia, Ivernia and Carinthia—Sylvania was built by John Brown & Co. (Clydebank) Ltd., and like them, too, she has a funnel casing made from British Aluminium plate and sections.

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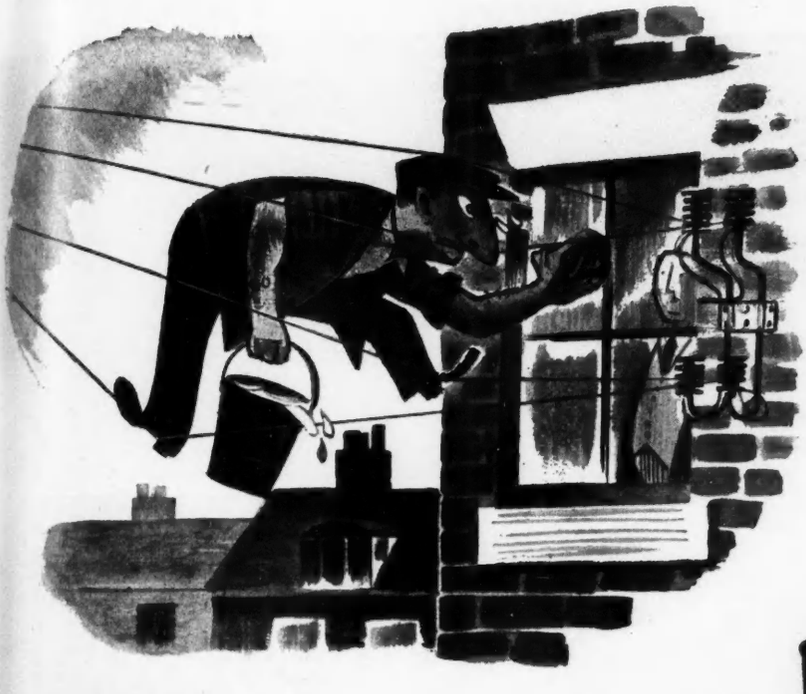

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There's danger as well as hard labour in cleaning Boilers the old way—danger of damage by corrosion and by the too strenuous use of chipping hammers. "*Apexior Number 1*" eliminates these dangers; saves time, labour and fuel.

Two coats of "*Apexior Number 1*", easily applied by brush or mechanical equipment to internal surfaces, ensure absolute protection from corrosion for at least 12 months. Scale is much reduced and its character so altered that it is looser in texture, less adherent. Heat transmission is greatly increased, thus saving fuel. "*Apexior Number 1*" is specially prepared to resist wet-heat temperatures between 175°-1000°F.

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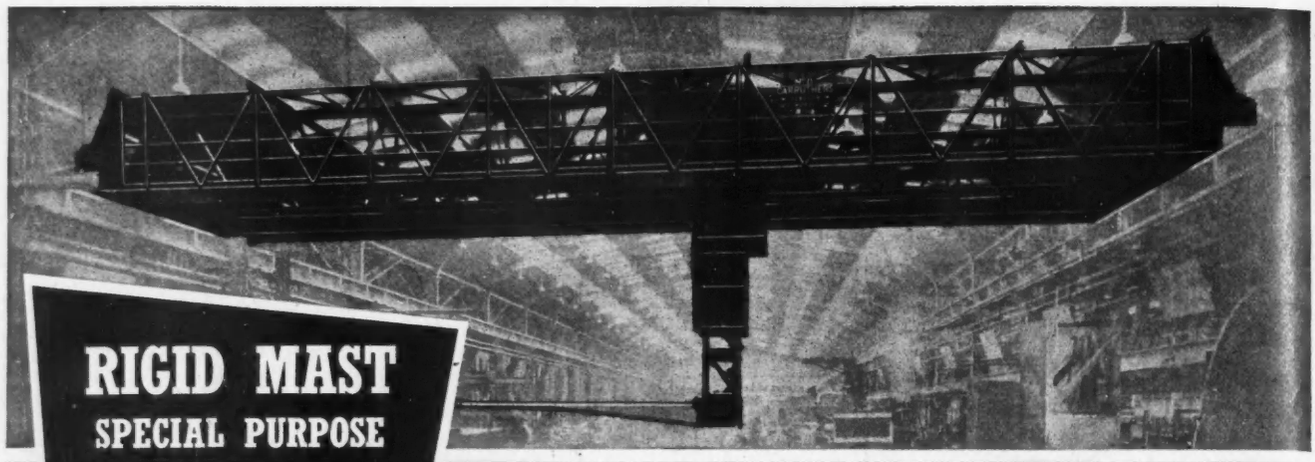

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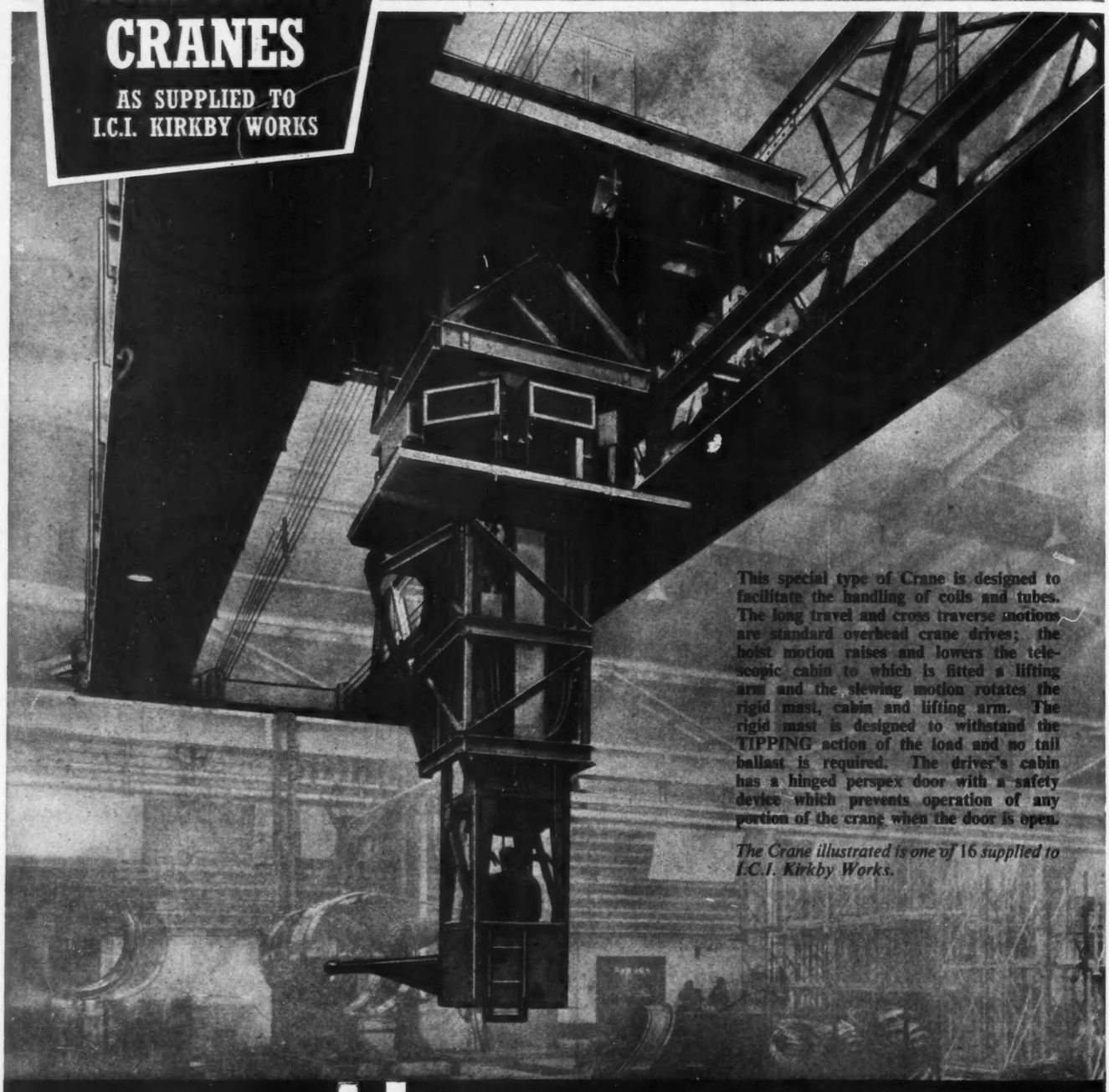

This special type of Crane is designed to facilitate the handling of coils and tubes. The long travel and cross traverse motions are standard overhead crane drives; the hoist motion raises and lowers the telescopic cabin to which is fitted a lifting arm and the slewing motion rotates the rigid mast, cabin and lifting arm. The rigid mast is designed to withstand the TIPPING action of the load and no tail ballast is required. The driver's cabin has a hinged perspex door with a safety device which prevents operation of any portion of the crane when the door is open.

The Crane illustrated is one of 16 *supplied to I.C.I. Kirkby Works.*

carruthers' cranes

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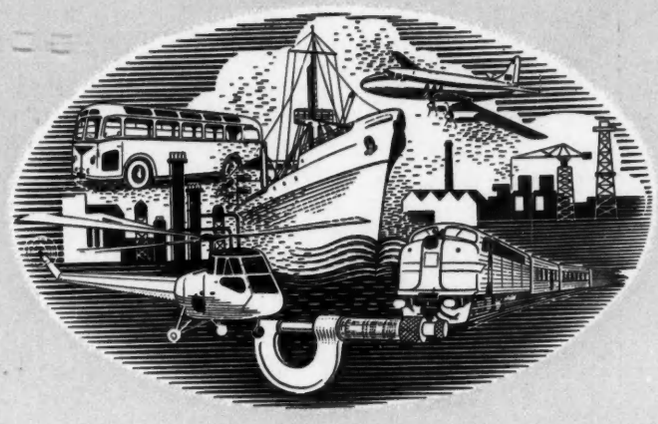

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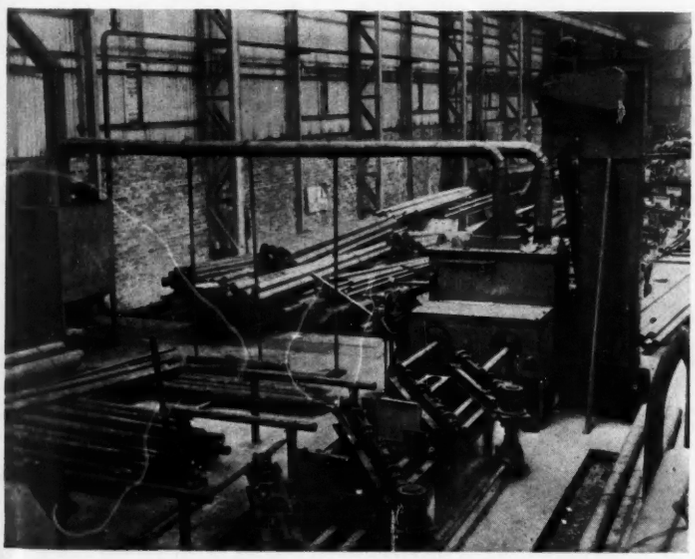

Photograph by kind permission of Weldless Steel Tube Co. Ltd., Wednesfield.

SPECIAL PURPOSE
SHOT BLAST EQUIPMENT

A TYPICAL EXAMPLE IS TO BE SEEN IN THE PHOTOGRAPH, WHICH SHOWS AN AIRLESS PLANT WITH A SINGLE IMPELLOR CLEANING TWO TUBES SIMULTANEOUSLY. THE TUBES ARE ROTATED AND TRAVERSED BY ROLLERS. THE PLANT IS SUITABLE FOR TUBES FROM 2ins. DIA. TO 10ins. DIA.

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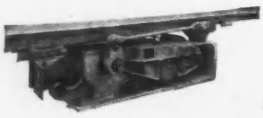
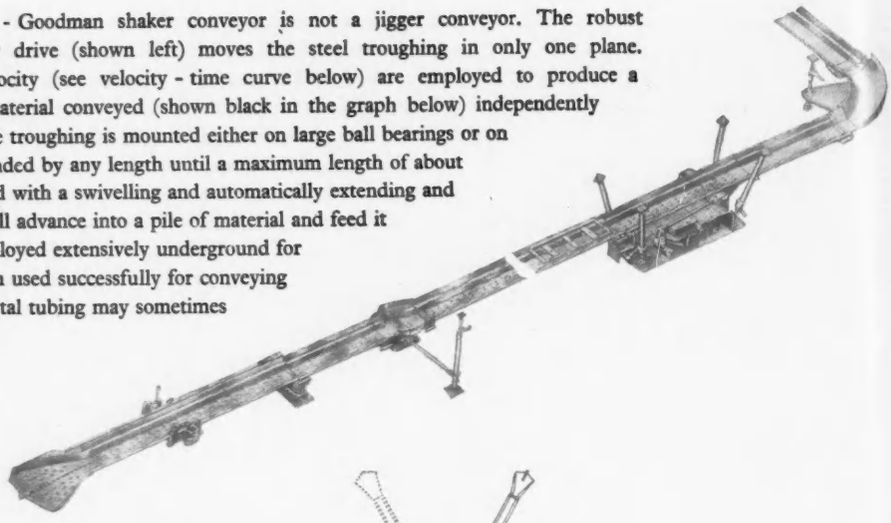
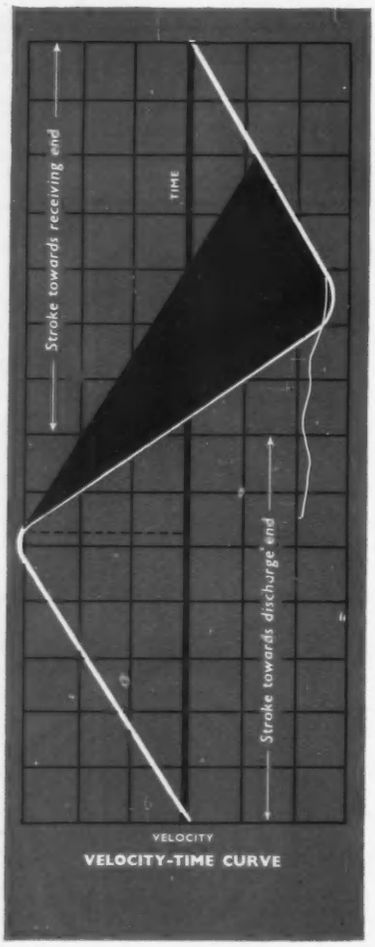


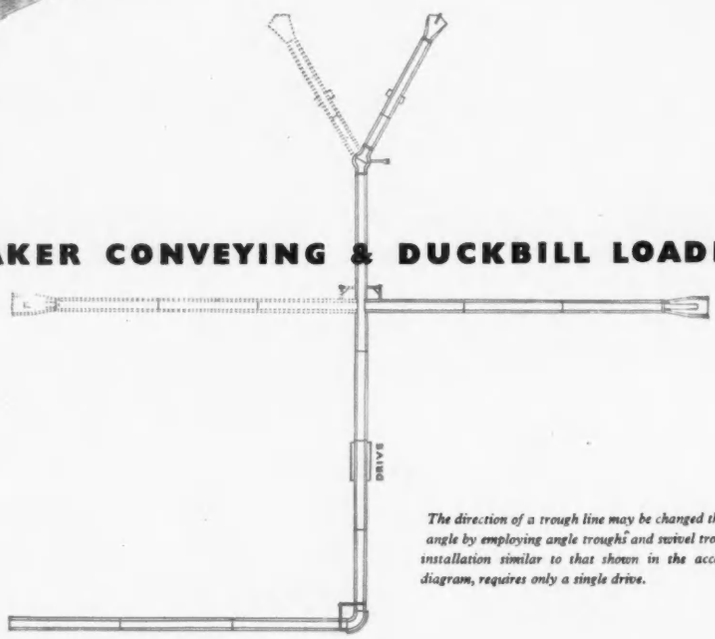
The Distington - Goodman shaker conveyor is not a jigger conveyor. The robust powerful shaker drive (shown left) moves the steel troughing in only one plane. Changes in velocity (see velocity - time curve below) are employed to produce a movement of the material conveyed (shown black in the graph below) independently from the troughing. The troughing is mounted either on large ball bearings or on rollers fitted with ball bearings and is easily extended by any length until a maximum length of about 100 yards is reached. The troughing may be fitted with a swivelling and automatically extending and retracting self-loading "duckbill" head which will advance into a pile of material and feed it onto the conveyor. This machinery has been employed extensively underground for loading and conveying coal and rock and has been used successfully for conveying hot materials in industries other than mining. Metal tubing may sometimes be employed instead of troughing.





VELOCITY-TIME CURVE

SHAKER CONVEYING & DUCKBILL LOADING

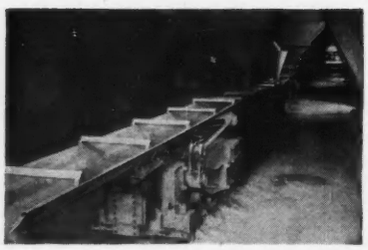


The direction of a trough line may be changed through any angle by employing angle troughs and swivel troughs. An installation similar to that shown in the accompanying diagram, requires only a single drive.

A single duckbill and shaker conveyor can load material anywhere in this stockyard and convey it to a crushing plant.

Shaker conveyor carrying hot sand and small castings in a mechanised foundry.

DISTINGTON



Shaker conveyor carrying sinter fines at temperatures sometimes reaching 300°C.

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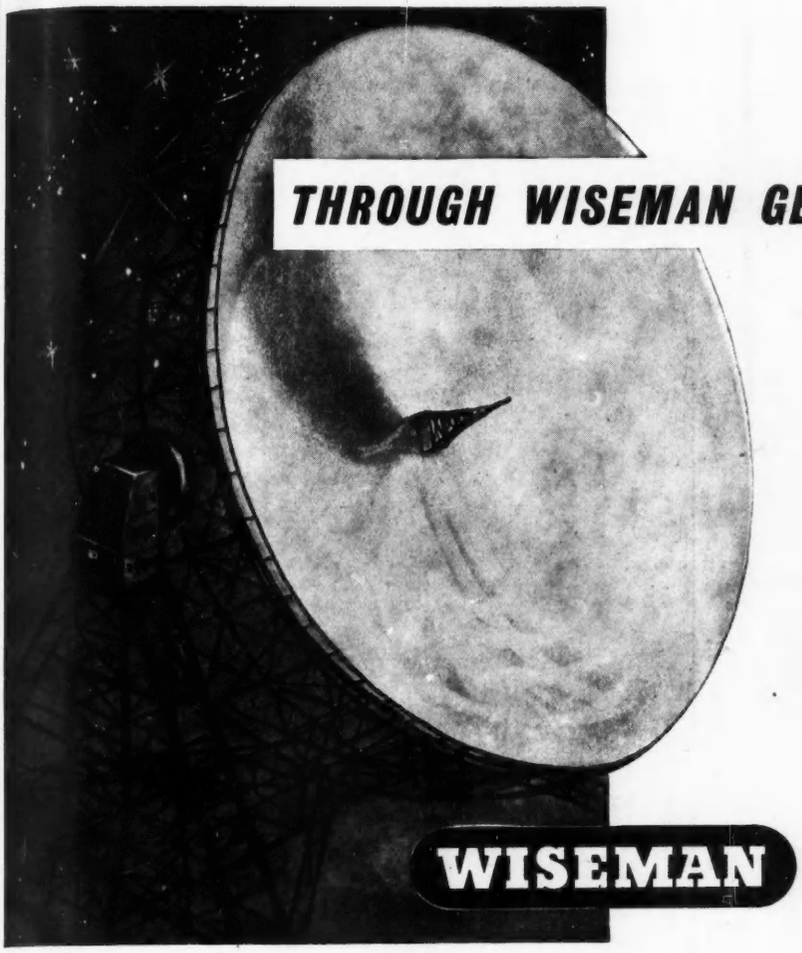

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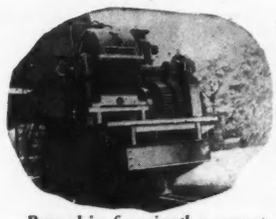
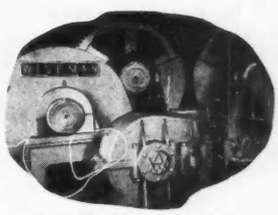


Bogey drive for azimuth movement



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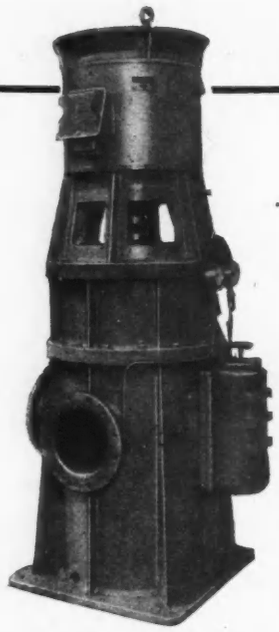

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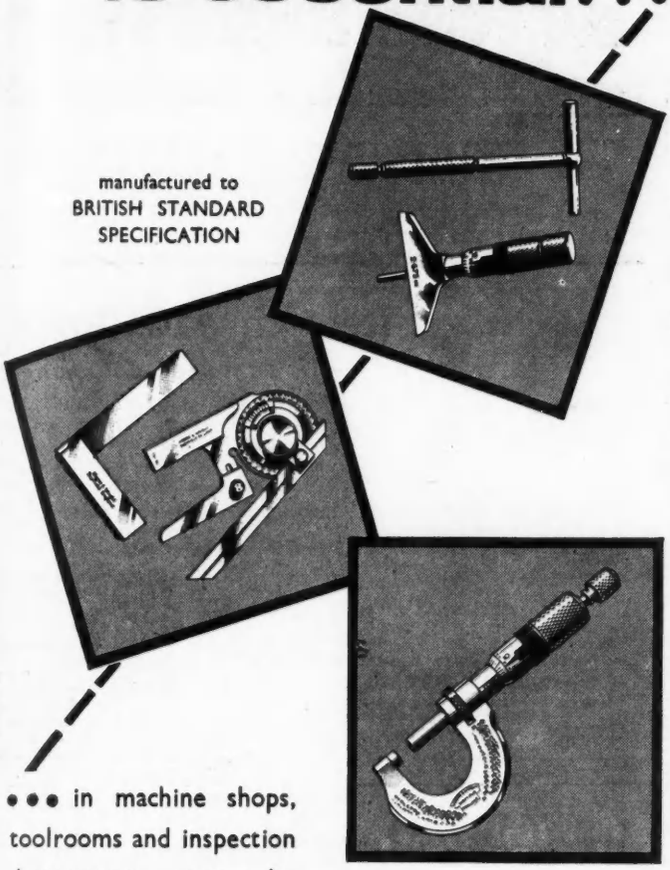

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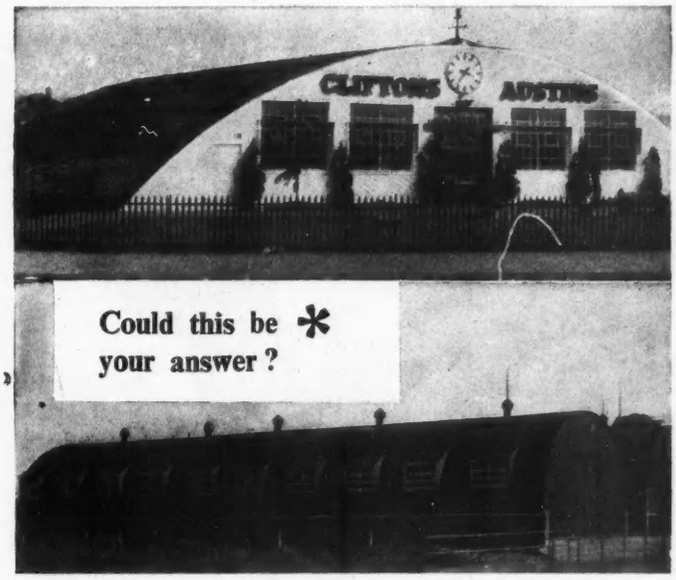

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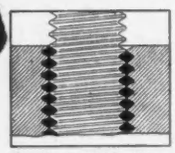

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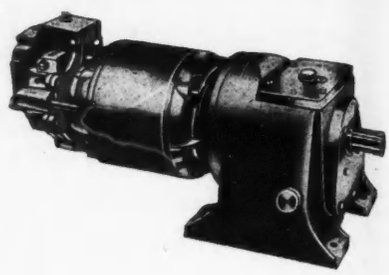

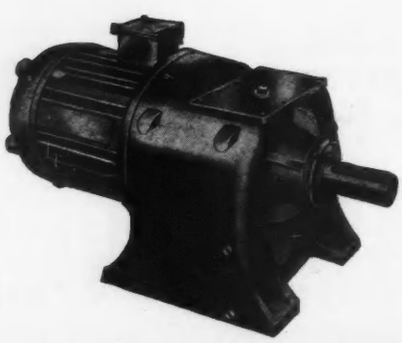

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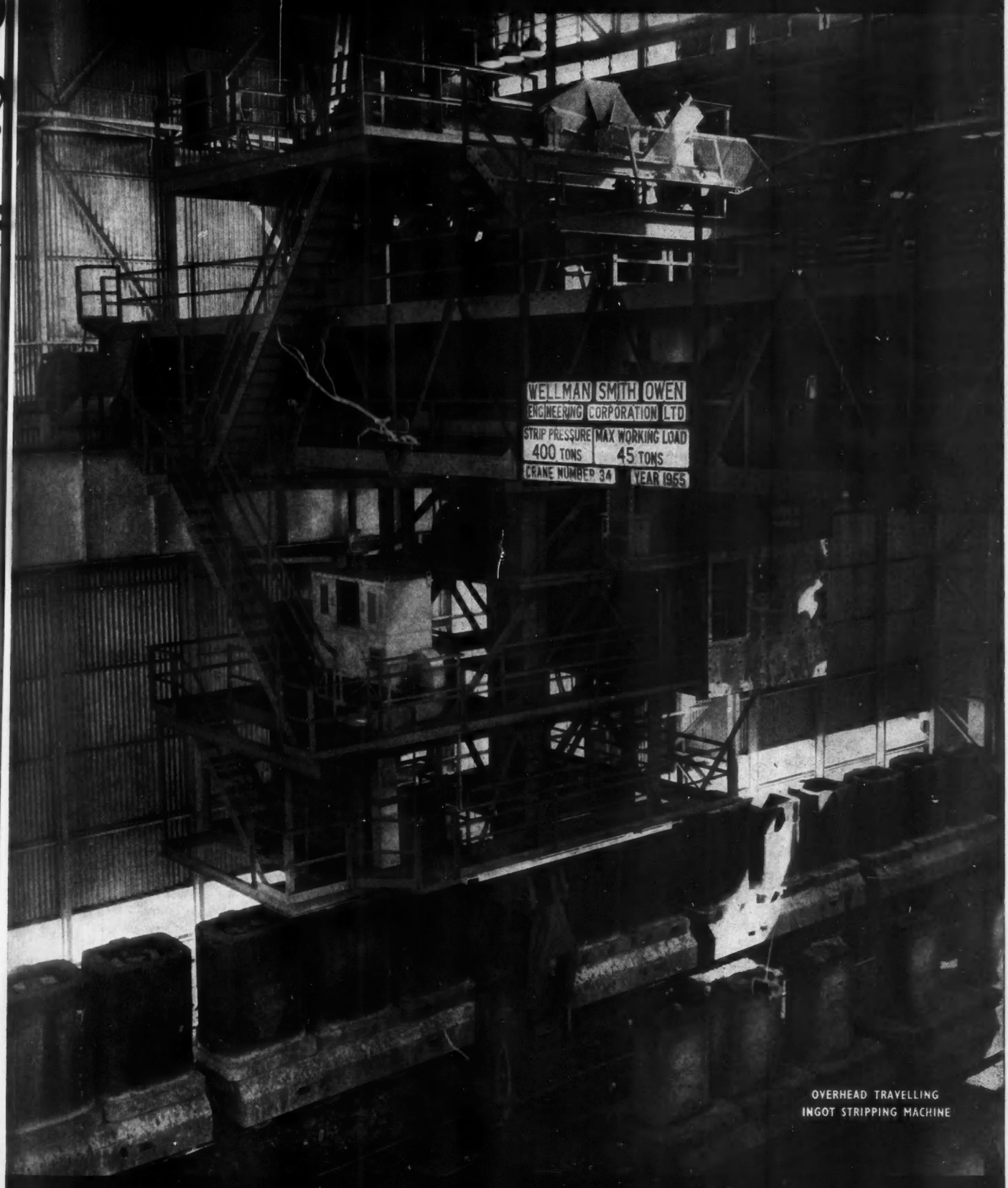

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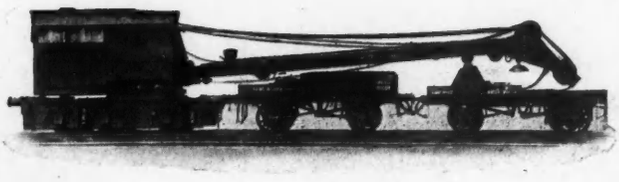

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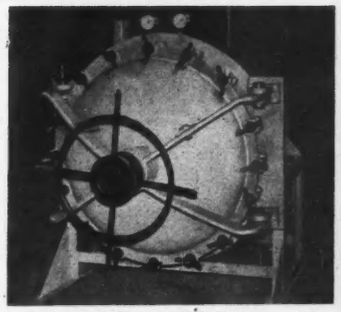

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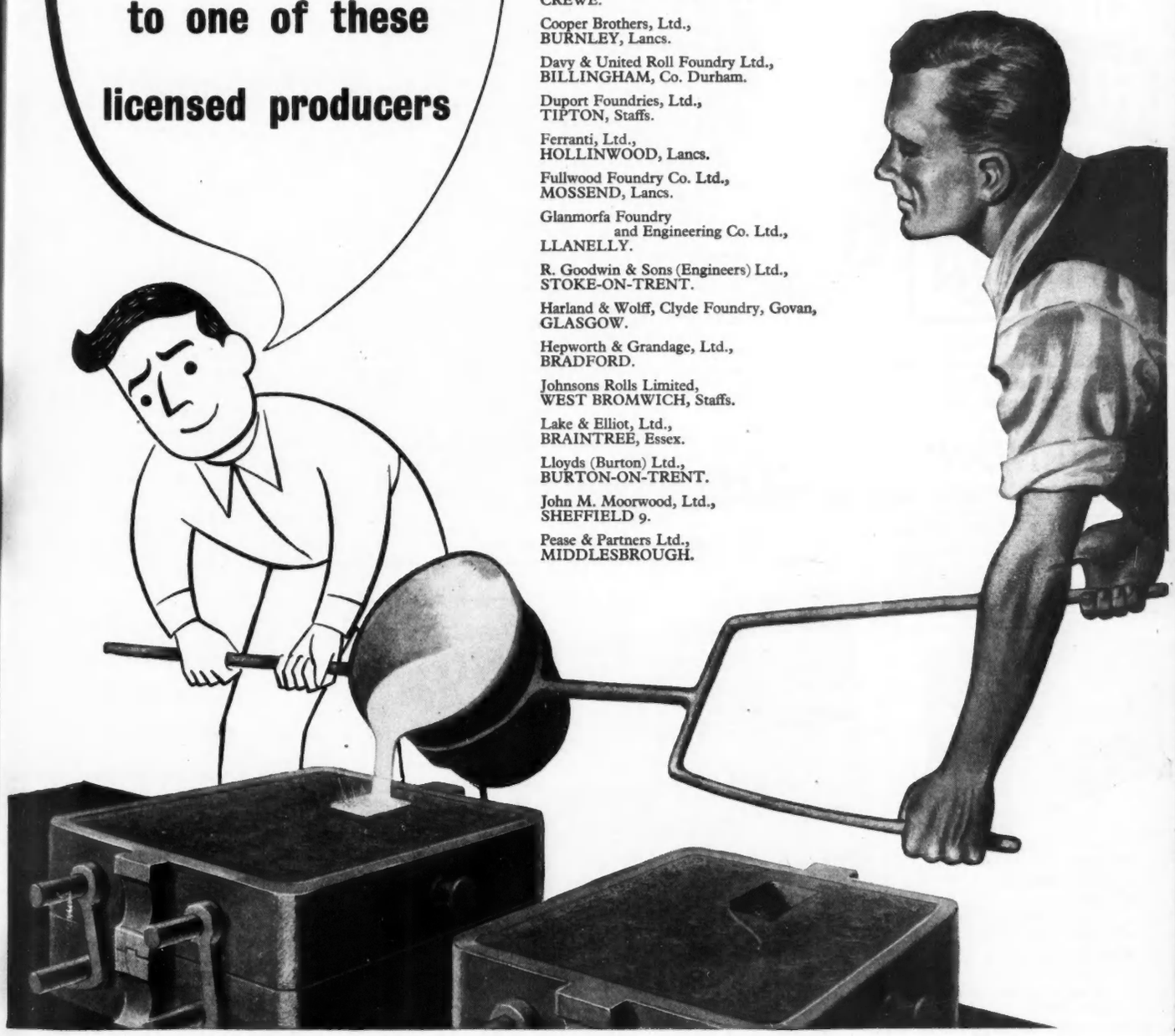

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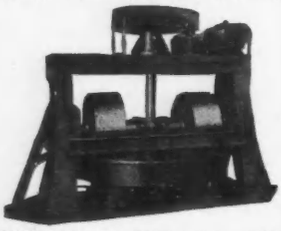

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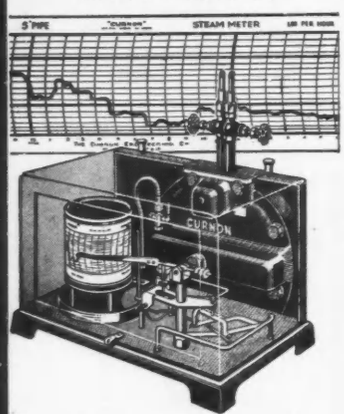

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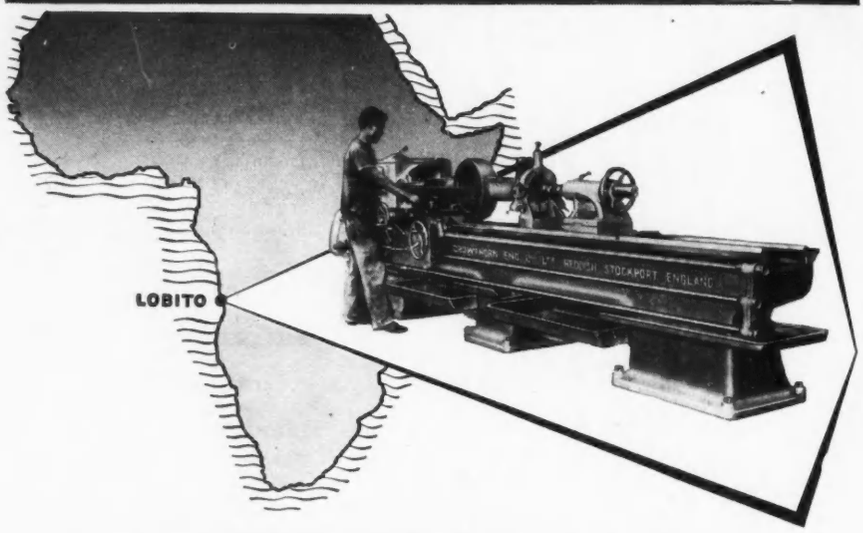

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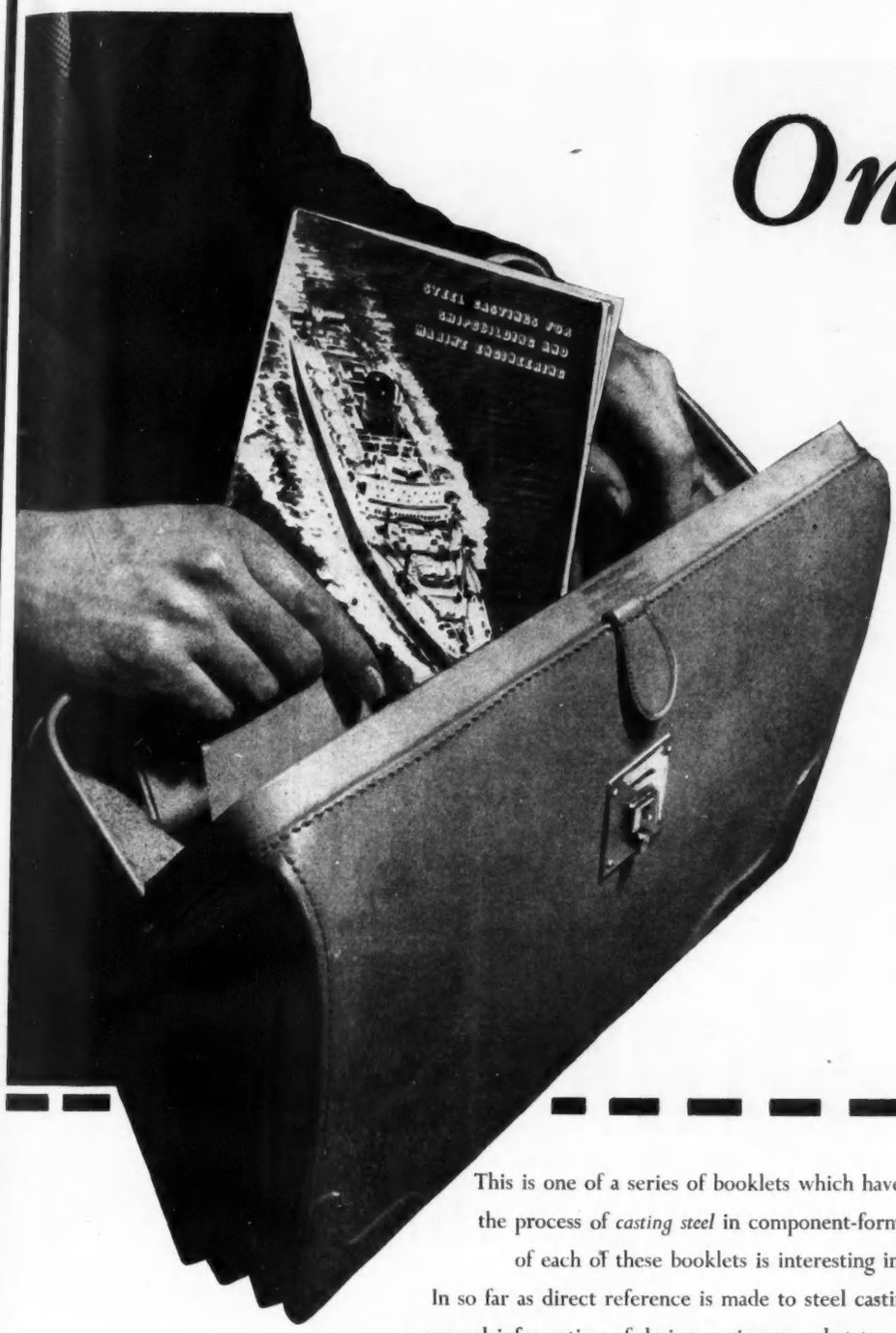

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This is one of a series of booklets which have been published to show how widely used is the process of *casting steel* in component-forms. But, apart from this function, the content of each of these booklets is interesting in its own right and well worth reading. In so far as direct reference is made to steel castings, it is to describe and illustrate for the general information of design engineers, what types of components are being cast in steel by the particular industry which is dealt with in any one booklet. So far there are eight titles in this series, covering the following industries:

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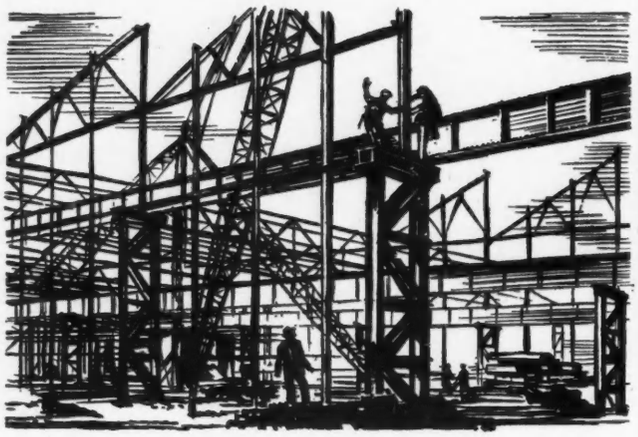

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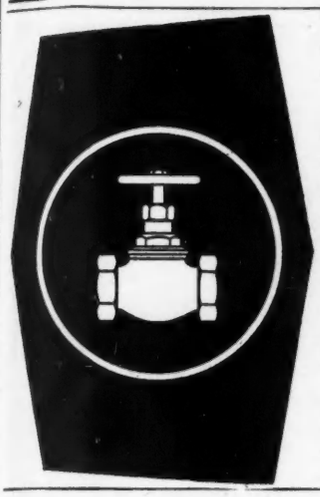

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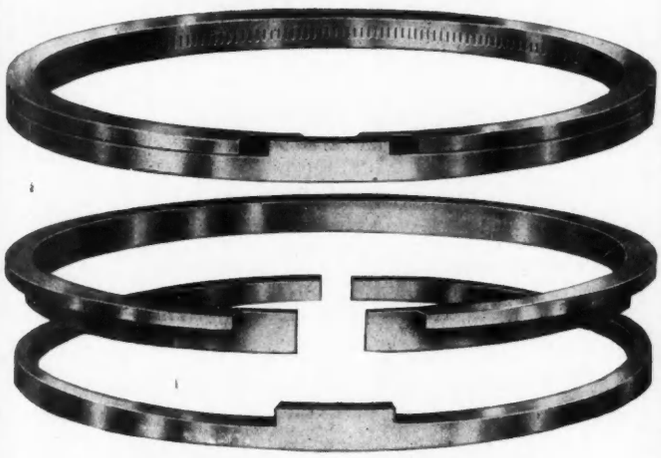

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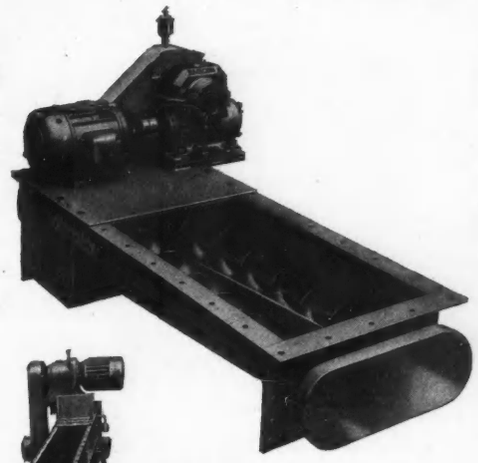

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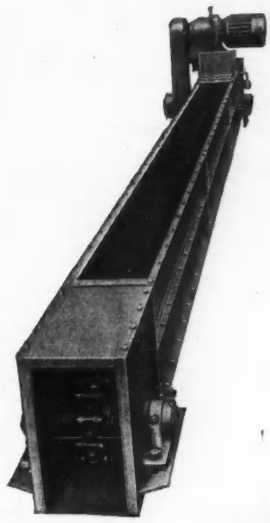

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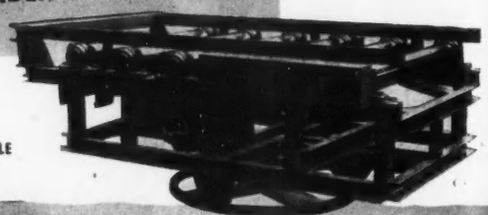

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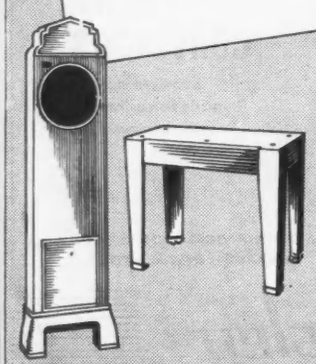

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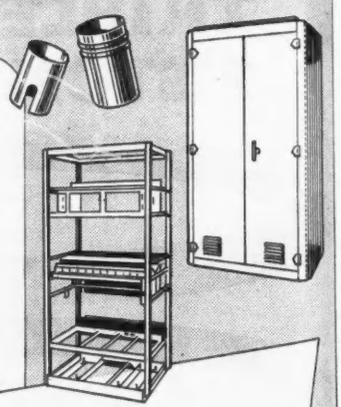

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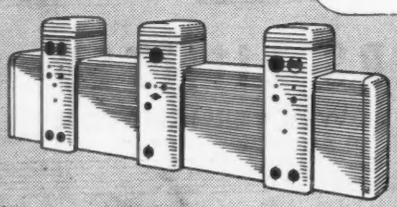

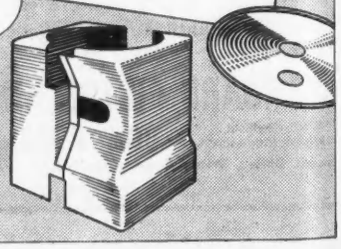

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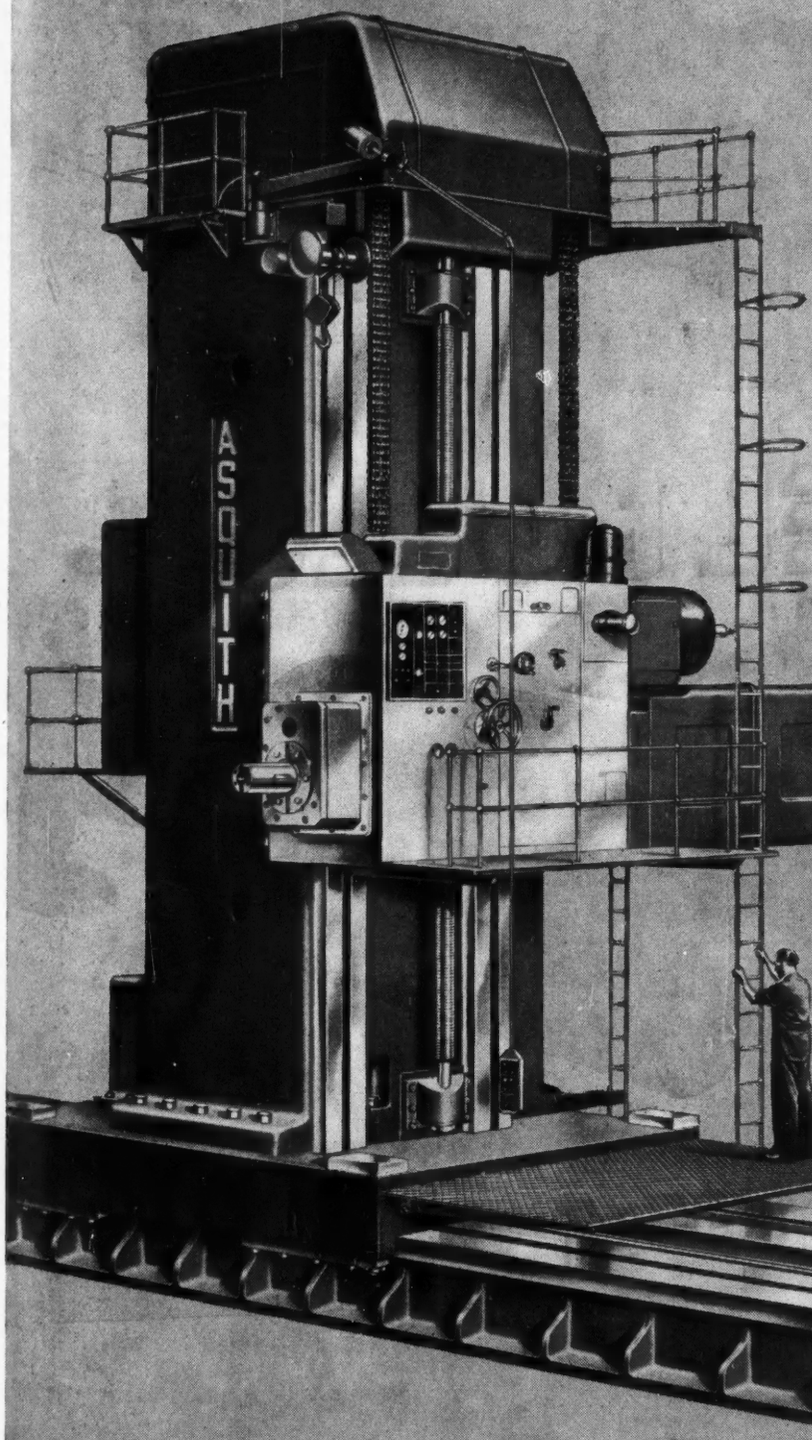

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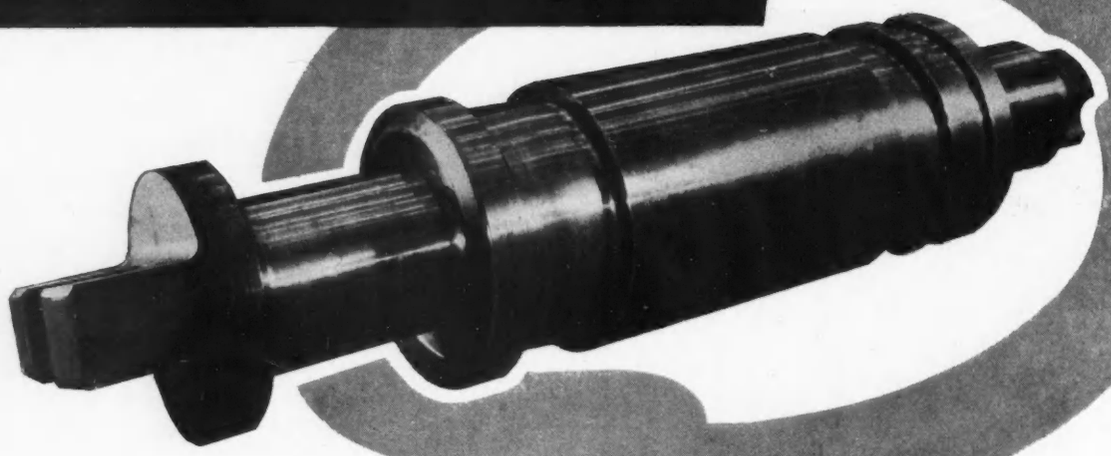

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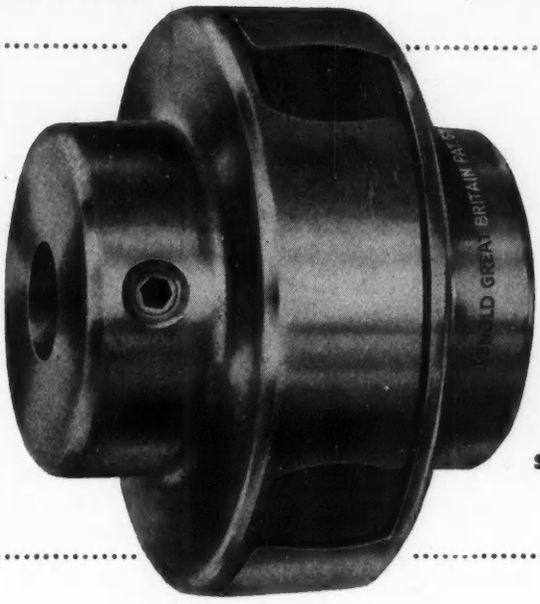

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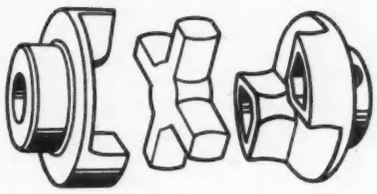

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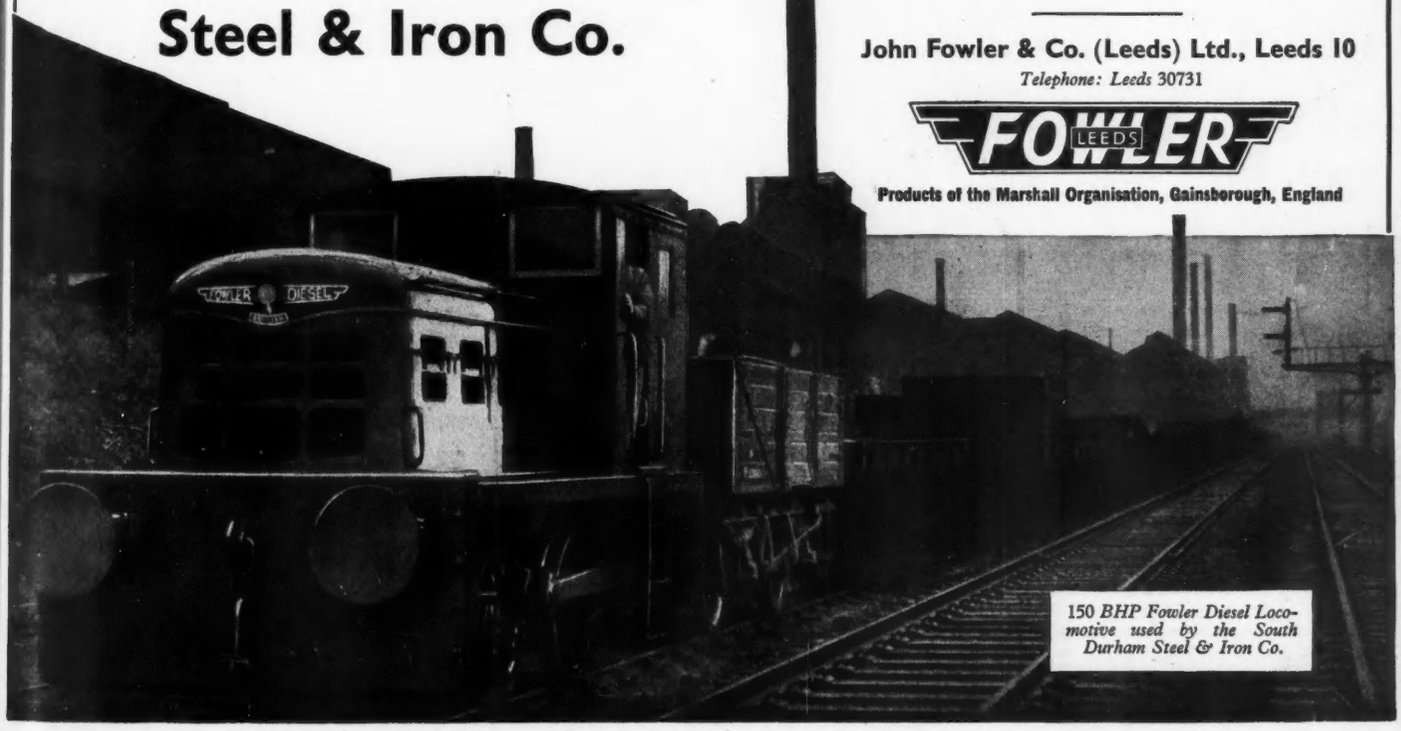

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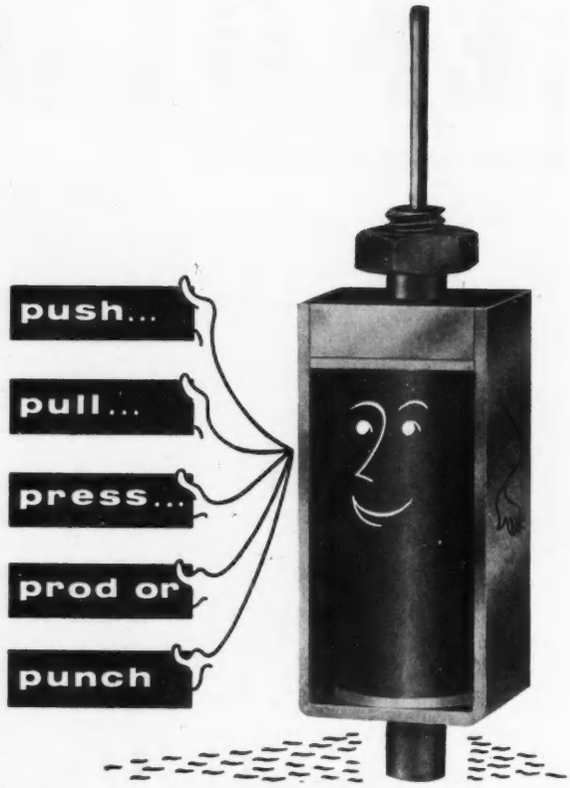

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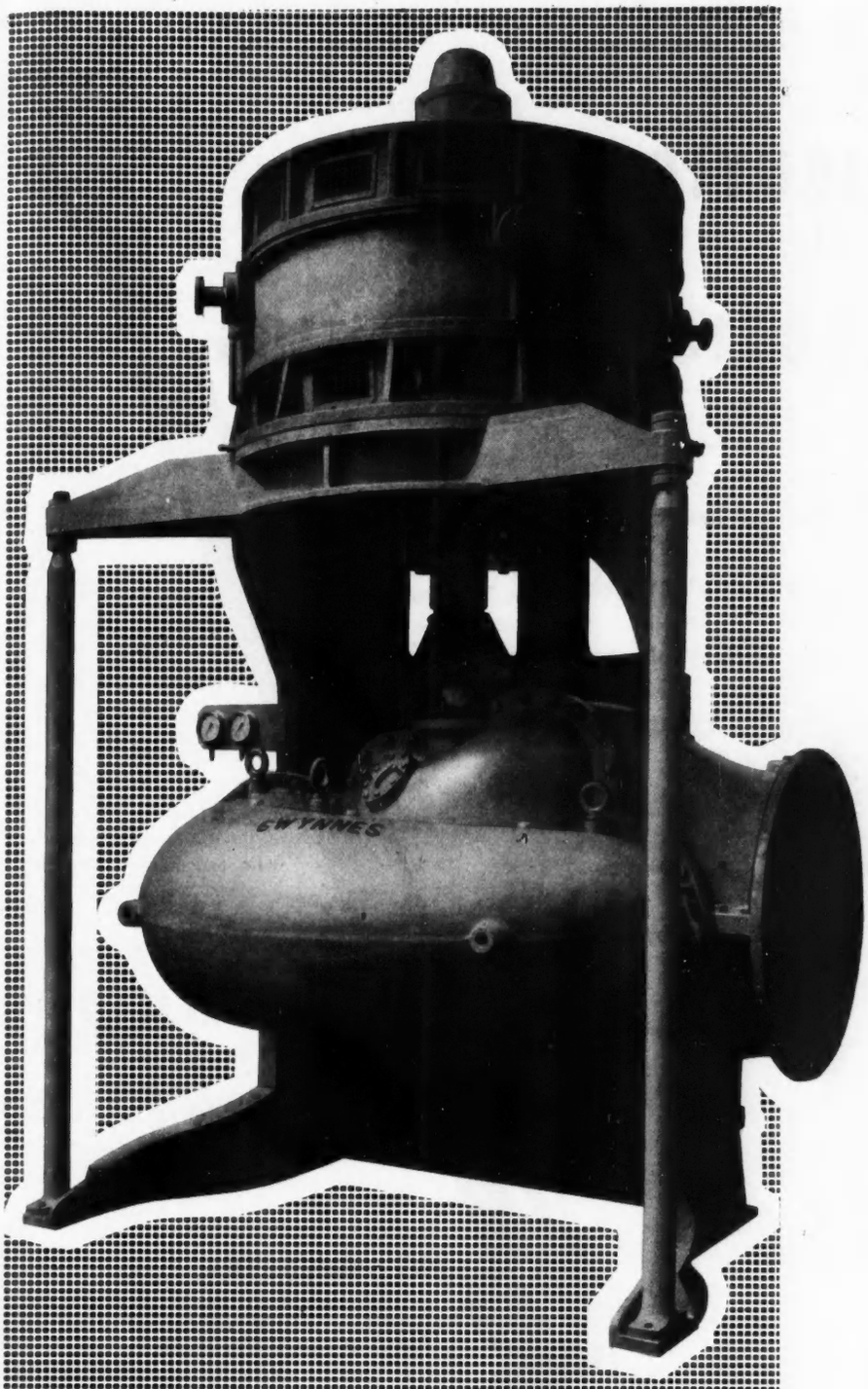

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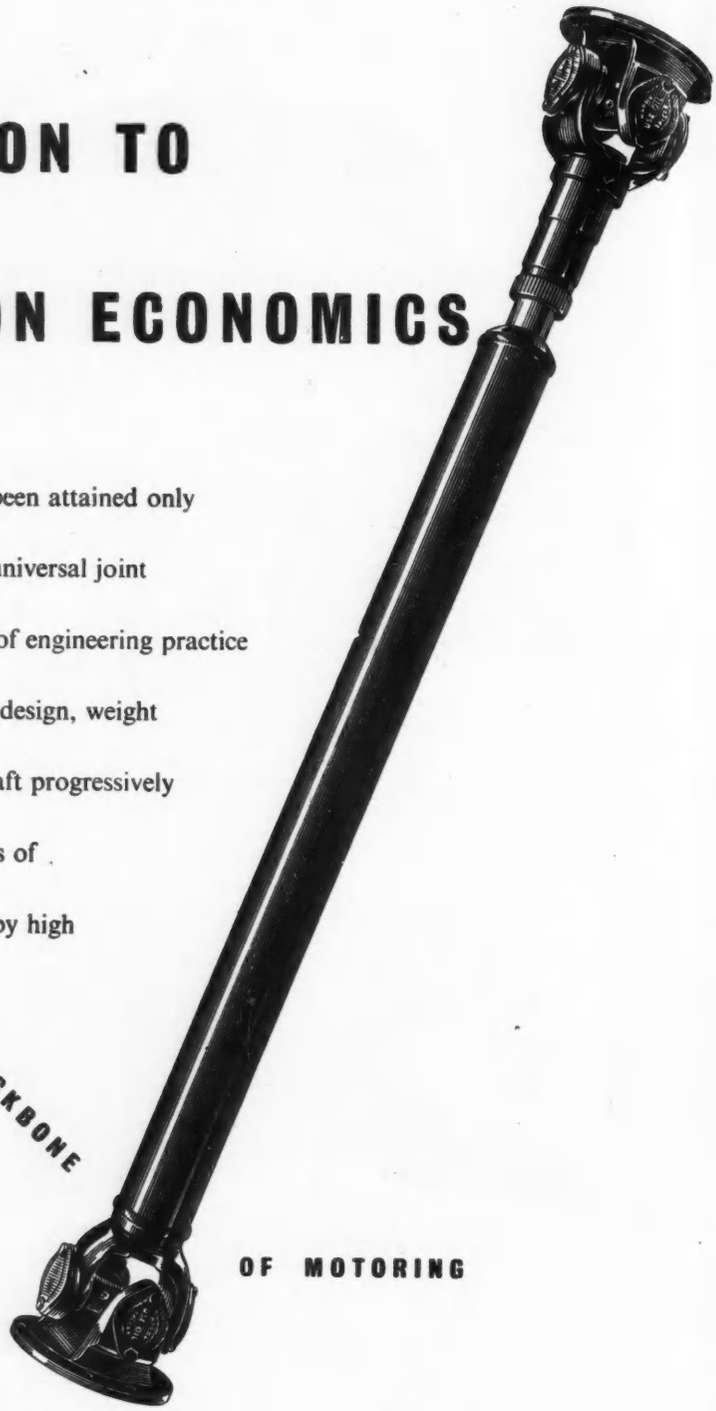

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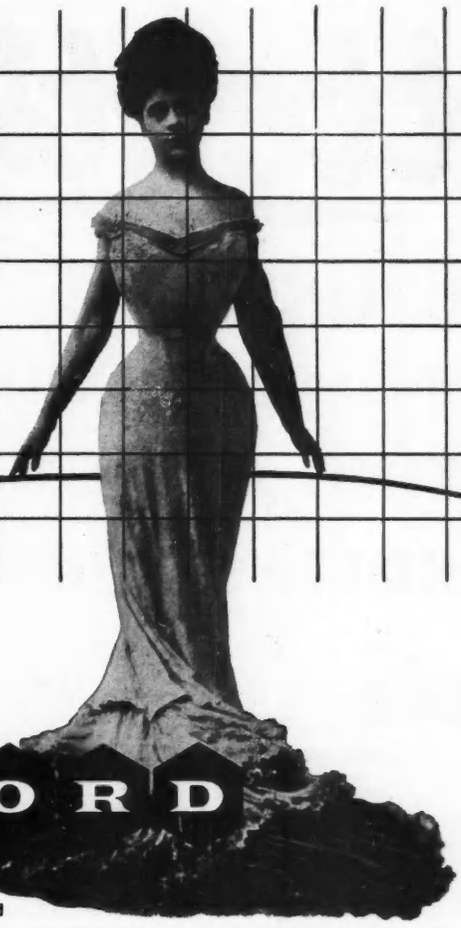

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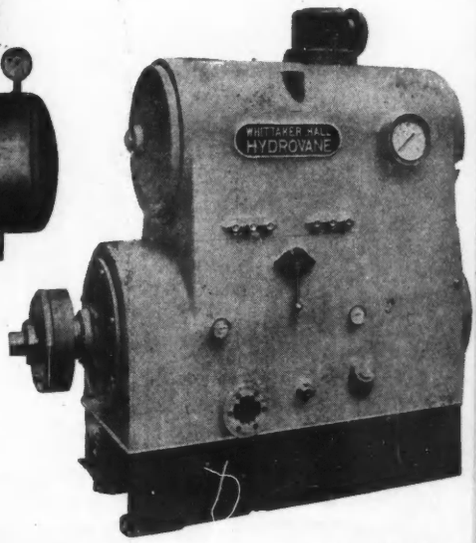

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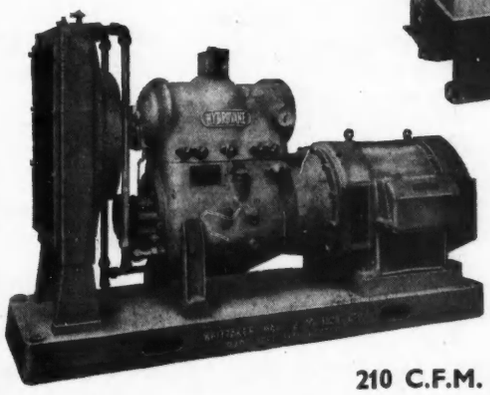

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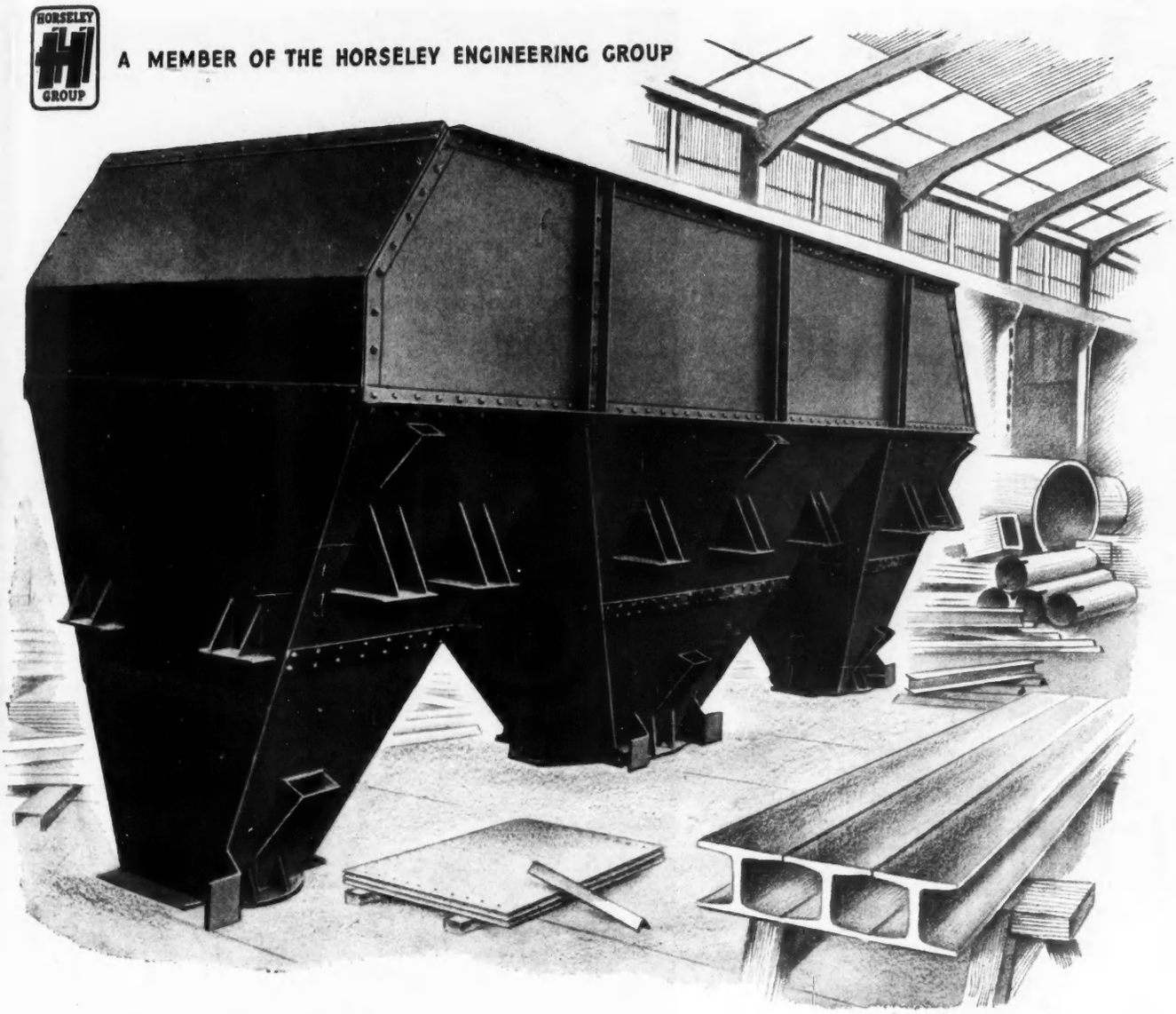

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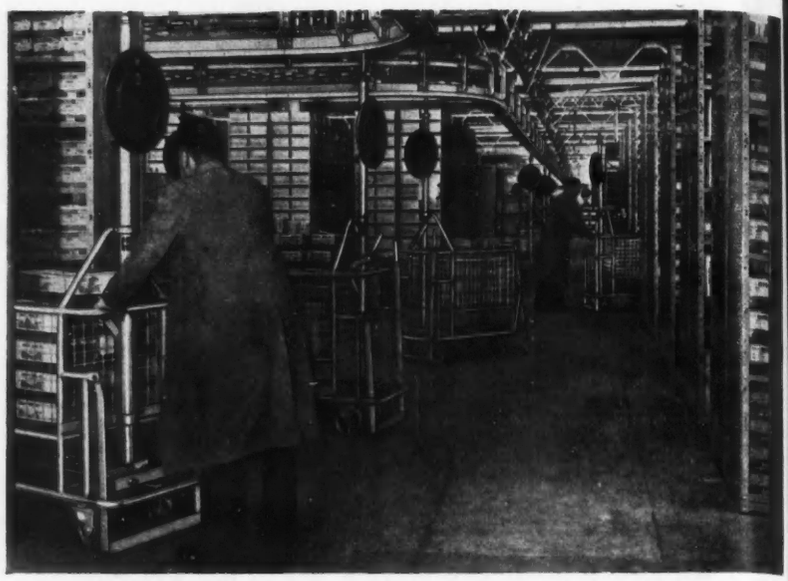

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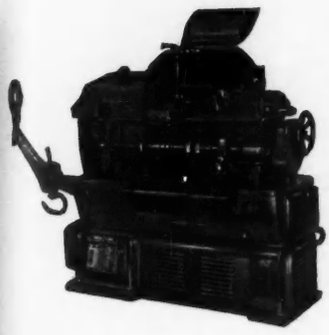

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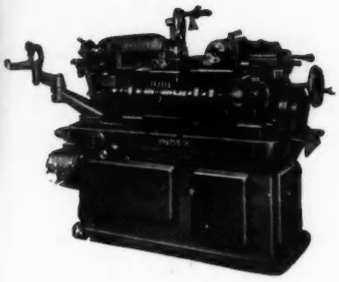

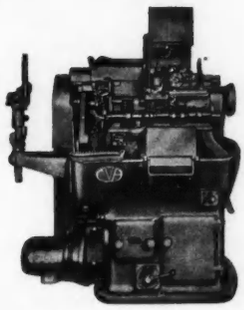

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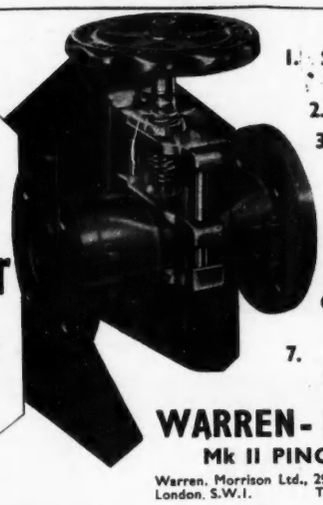

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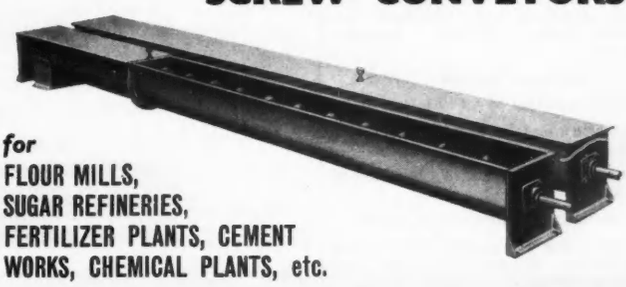

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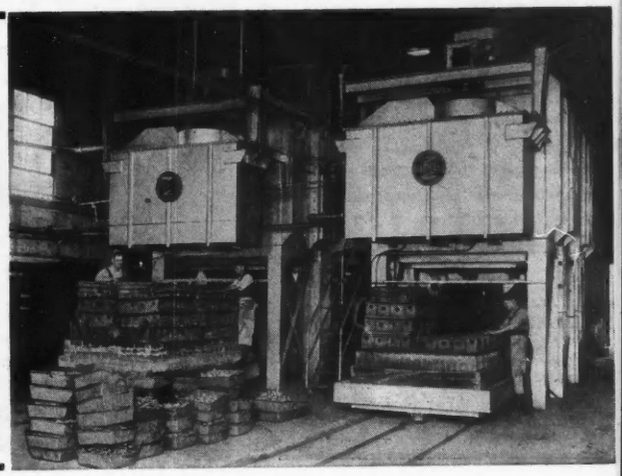

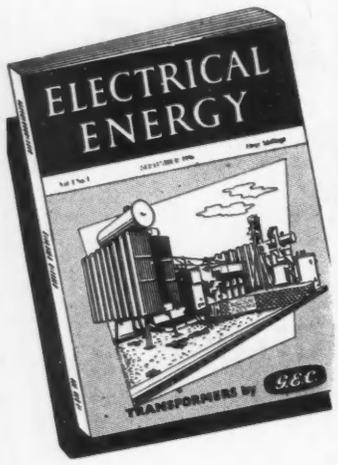

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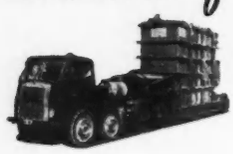

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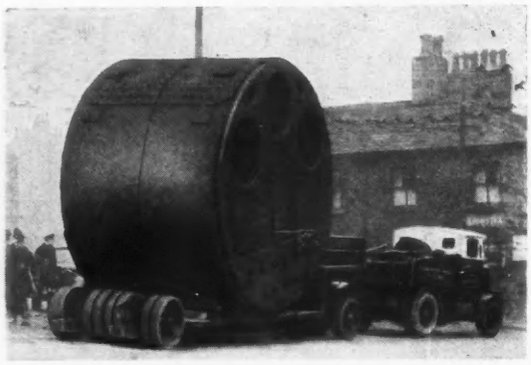

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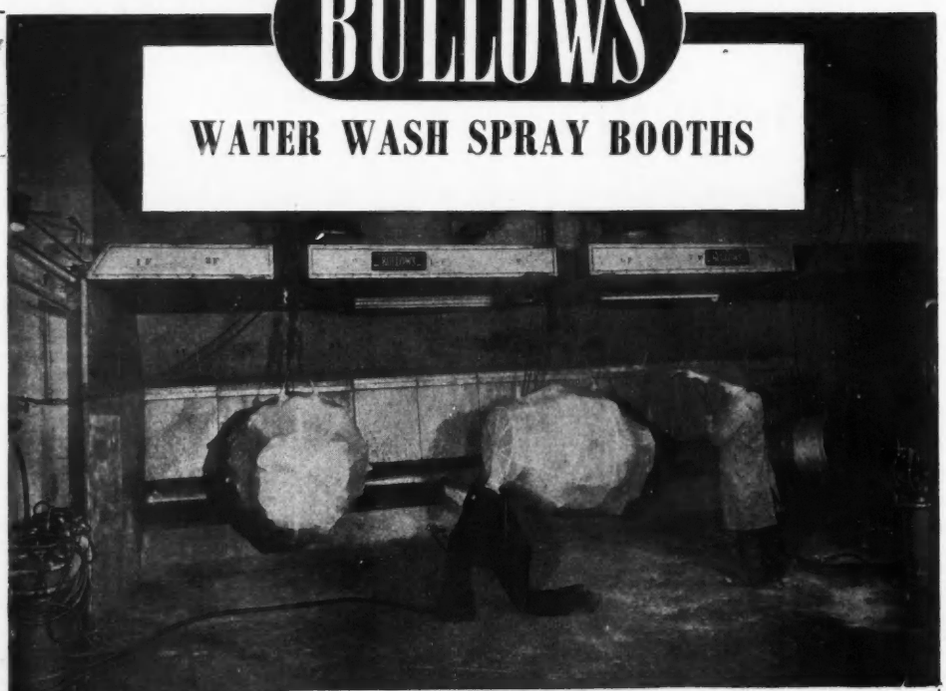

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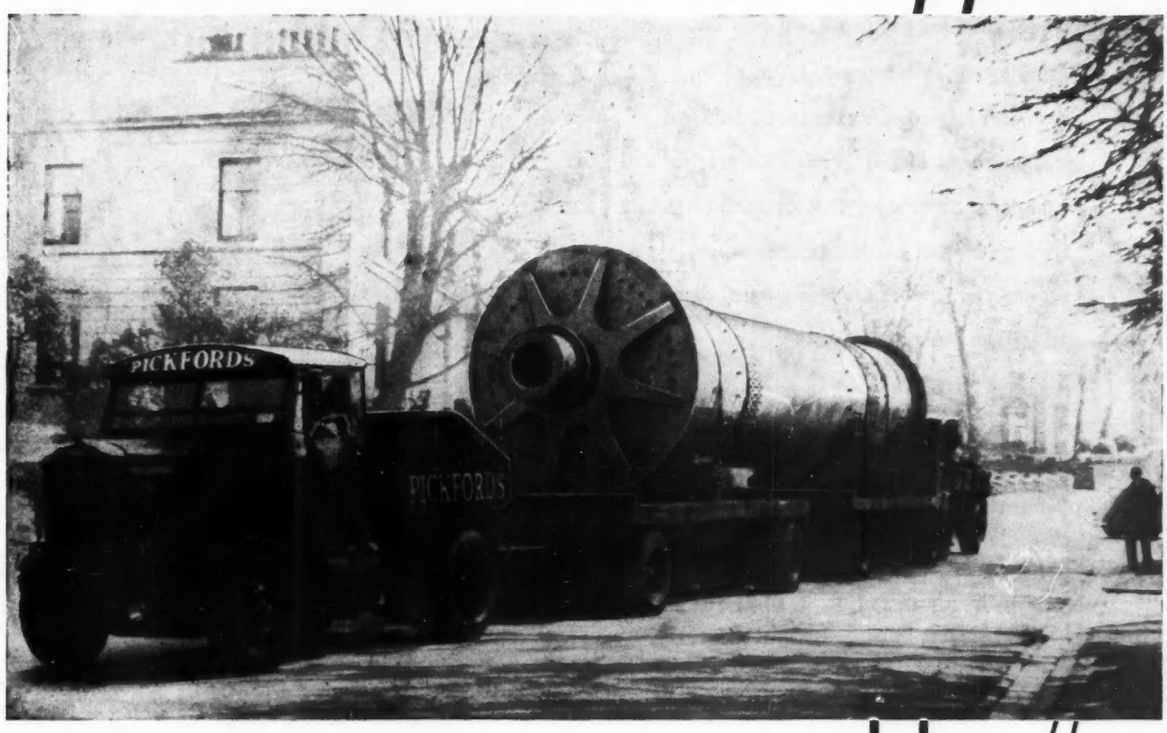

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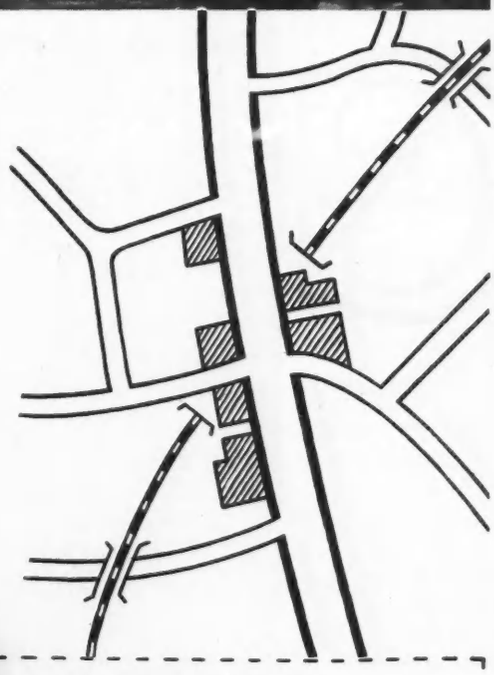

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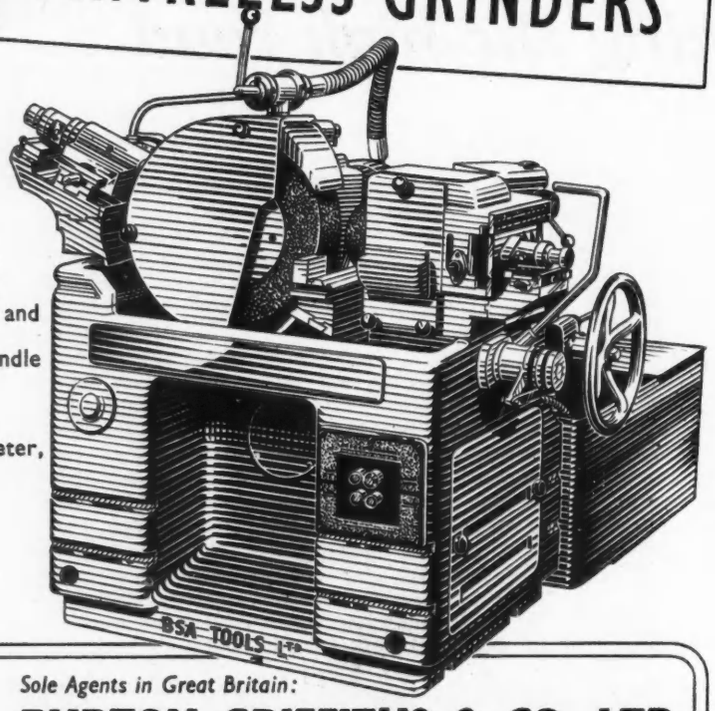

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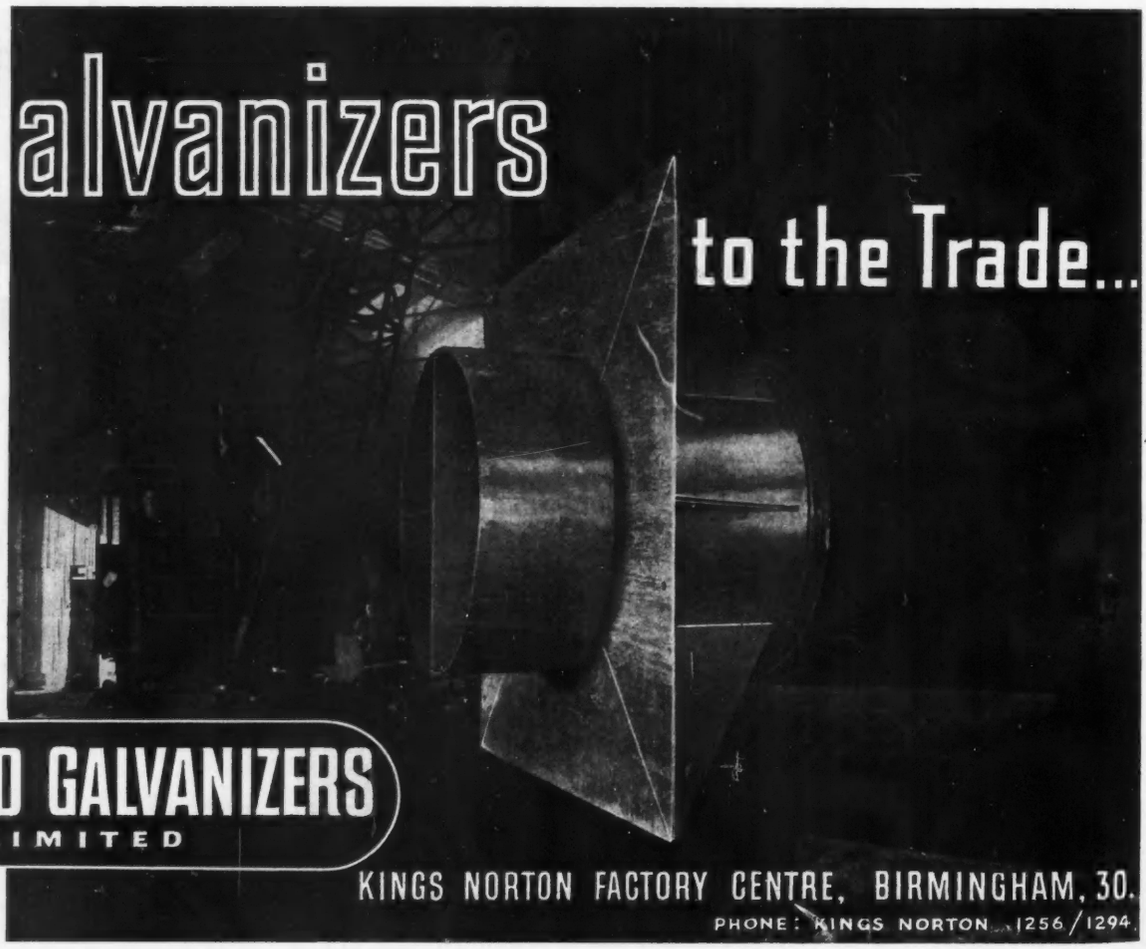

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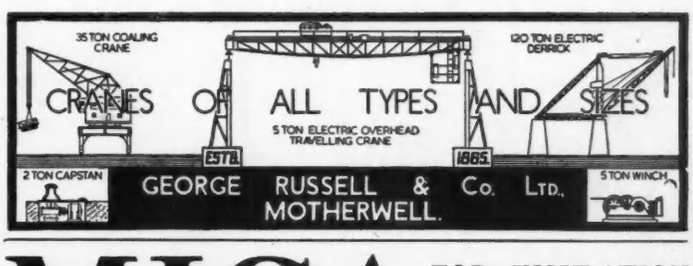

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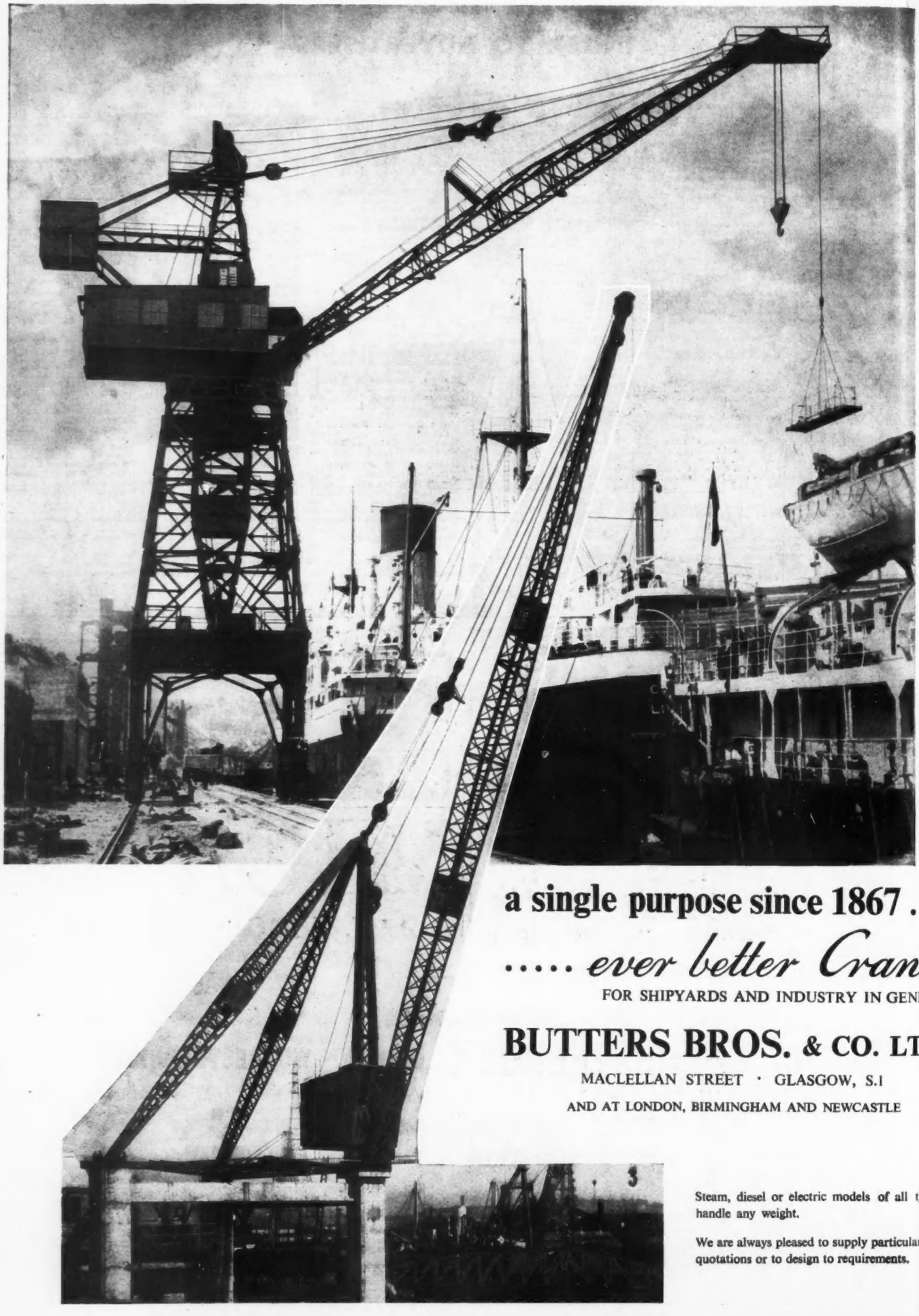

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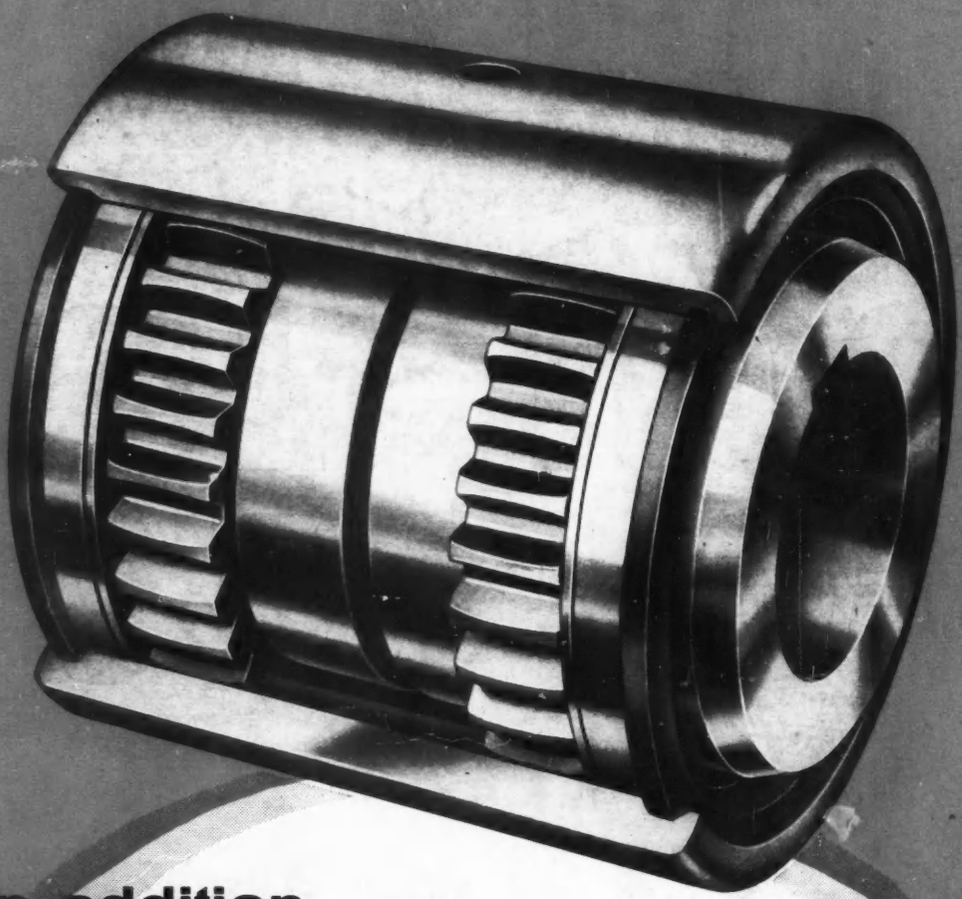

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